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PROFESSOR EINSTEIN AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

ADDRESSES AT THE DINNER IN HIS HONOR[1]

MR. ALLAN C. BALCH, PRESIDENT OF THE ATHENAEUM:

THIS is a dinner of some two hundred California Institute Associates, held at the Athenaeum, a building designed as a club house and meeting center for three groups of people: First, the staffs of the three adjacent cooperating institutions, the California Institute of Technology, the Mount Wilson Observatory of the Carnegie Institution of Washington and the Henry E. Huntington Library and Art Gallery; second, eastern and foreign scholars who are drawn to this research and educational center for participation in, or some sort of association with, its activities; third, the group of residents of this Southern California community known as the California Institute Associates, who are interested in and promotors of the scientific and scholarly work going on in these institutions.

I wish to call first on Russell H. Ballard, president of the Southern California Edison Company and president, also, of the California Institute Associates.

MR. BALLARD:

Mr. Balch, Professor Einstein and the California Institute Associates:

It is rare good fortune that there is at this moment a conjunction here at the Athenaeum of a large number of the men who have worked as colaborers in the development of those phases of modern knowledge and modern thought to which the guest of honor tonight has made far-reaching contributions. I am going to call the roll, in the order of seniority, of this group of Einstein collaborators here present:

Albert A. Michelson, emeritus director of the Ryer-

[1] The Athenaeum, California Institute of Technology, January 15, 1931.

son Physical Laboratory of the University of Chicago, now a permanent resident of Pasadena and an associate of both the California Institute and the Mount Wilson Observatory; Charles E. St. John, astrophysicist of the Mount Wilson Observatory; William Wallace Campbell, president emeritus of the University of California and formerly director of the Lick Observatory; Robert A. Millikan, director of the Norman Bridge Laboratory of Physics of the California Institute; Albert Einstein, professor of theoretical physics of the University of Berlin; Walter S. Adams, director of the Mount Wilson Observatory; Richard C. Tolman, professor of physical chemistry and theoretical physics of the California Institute; Edwin P. Hubble, astrophysicist of the Mount Wilson Observatory.

This is just the sort of meeting the California Institute Associates will participate in, we hope, each year, and a number of times each year, throughout all the coming years, and I welcome you all to this first meeting of this sort in this new and extraordinarily beautiful Athenaeum.

MR. BALCH:

I now wish to call on Robert A. Millikan to act as toastmaster in the introduction of the scientific speakers.

DR. MILLIKAN:

The distinguishing feature of modern scientific thought lies in the fact that it begins by discarding all *a priori* conceptions about the nature of reality—or about the ultimate nature of the universe—such as had characterized practically all Greek philosophy and all medieval thinking as well, and takes instead, as its starting point, well-authenticated, carefully tested experimental facts, no matter whether these facts seem at the moment to fit into any general philosophical scheme or not—that is, no matter whether they seem at the moment to be reasonable or not. In a word, modern science is essentially empirical, and no one has done more to make it so than the theoretical physicist, Albert Einstein. That, in a sentence, is, I take it, his greatest contribution to modern thought. It will stand out repeatedly in all that is said to-night.

Throughout the nineteenth century we had been building up what seemed a wonderfully consistent "natural philosophy" as to the nature of radiant energy—a beautiful wave-theory of light. Professor Michelson's own researches on interference had furnished some of its strongest supports. This theory required that it be possible, by noting the difference in time required for a beam of light to get back to the observer when, on the one hand, it was sent forth in the direction of the earth's motion and back by reflection from a mirror to the observer, and when, on the other hand, it was sent a like distance forth and back at right angles to the earth's motion, to find the speed with which the earth is moving through the ether. But this experiment, when first performed with extraordinary skill and refinement by Michelson and Morley in 1887, yielded with great definiteness the answer that there is no such time-difference and therefore no observable velocity of the earth with respect to the ether. That unreasonable, apparently inexplicable experimental fact has now been checked by a multitude of observers—very recently and very carefully by Michelson himself, and also in extraordinarily exact measurements by Roy J. Kennedy at the California Institute, so that it is now a well-authenticated fact.

For twenty years after this fact came to light physicists wandered in the wilderness in the disheartening effort to make it seem reasonable. Then Einstein called out to us all, "Let us merely accept this as an established experimental fact and proceed to work out its inevitable consequences," and he went at that task himself with an energy and a capacity which very few people on earth possess. Thus was born the special theory of relativity, and I now wish to introduce the man who laid its experimental foundations, Professor Albert A. Michelson, my own chief and my adviser and friend for twenty-five years at the University of Chicago, the man who gave me my own opportunity in physics, and by his own example—the greatest of stimulants—showed me how to use it.

DR. MICHELSON:

I very highly appreciate this opportunity of greeting Dr. and Mrs. Einstein and welcoming them to our institute. We consider it one of the highest honors and trust that the stay of our guest of honor may be so delightful that he will take frequent opportunities of repeating the experience. I consider it particularly fortunate for myself to be able to express to Dr. Einstein my appreciation of the honor and distinction he has conferred upon me for the result which he so generously attributes to the experiments made half a century ago in connection with Professor Morley, and which he is so generous as to acknowledge as being a contribution on the experimental side which led to his famous theory of relativity. I may recall the fact that in making this experiment there was no conception of the tremendous consequences brought about by the great revolution which Dr. Einstein's theory of relativity has caused—a revolution in scientific thought unprecedented in the history of science.

In concluding, may I be permitted to congratulate

the trio, the California Institute of Technology, the Mount Wilson Observatory and the Huntington Library, and especially Dr. George E. Hale, whose influence brought about the realization of this dream. May it continue to prove the attraction which it has shown in bringing to these delightful precincts these celebrated men culminating in the presence of our distinguished guest.

DR. MILLIKAN:

You and I are not interested, nor should we be expected to be interested, in just how Professor Einstein worked out the consequences of his assumption that it is impossible to detect the motion of the earth with respect to space, nor indeed in what additional postulates he had to make to round out the theory and make it more general so that it might cover not only predictions on the relations of bodies moving with constant relative velocities, but also predictions in cases in which rates of change of velocities, or accelerations, were involved. These are technical matters which we should no more expect to be able to follow into their details than we should expect to be able to follow the steps by which an astronomer computes the orbit of a planet, or an assayist analyzes a sample of ore. What we do wish to know, however, is simply this: Does the computation or the analysis yield results which can be experimentally verified? Professor Einstein himself has repeatedly assured us that his work must stand or fall by that test alone. I wish, therefore, to introduce to you now William Wallace Campbell, one of the group of experimental astronomers who has himself made one of the accurate tests of Einstein's predictions, and I am herewith assigning to him the task of sketching the development of the experimental credentials of the general theory of relativity.

DR. CAMPBELL:

When Professor Einstein published his immortal theory of relativity, a theory evolved within the four walls of his study room, he in effect advised his colleagues in the world of science to delay their acceptance of it until after it had been subjected to certain observational tests. He described three such tests all astronomical by which his theory must stand or fall.

Test No. 1: The theory of relativity, he said, must explain and remove the discrepancy between the predicted motion and the observed motion of the planet Mercury. This little brother of the earth, revolving around the sun at an average distance about one third as great as the earth's distance from the sun, refused to follow the path assigned to it by Sir Isaac Newton's law of gravitation. The discrepancy was very small, but nevertheless certain. For a half a century before Einstein, astronomers had sought diligently but in vain for the explanation. Promptly following the publication of Einstein's work, he himself as well as astronomer De Sitter of Holland applied the test to Mercury, and the theory of relativity accounted in full for the discrepancy referred to.

Test No. 2: The theory of relativity, he said, requires that a ray of light, say from a distant star, when passing close to the surface of our sun, should be bent slightly from its straight-line course by the gravitational pull of the sun upon the light ray and, in addition, as an effect of the curvature of the space in which the sun is immersed. That a ray of light should be subject to gravitational attraction and that space should be curved were results or hypotheses new to the world. Einstein urged that astronomers endeavor to observe the phenomenon at times of total solar eclipse, the only times when the test can be applied by photographing the eclipsed sun's surroundings in order to record on the photographic plates the images of the stars in the neighborhood of the sun—though of course these stars would be millions of times as far away from us as the sun is. The star images should be slightly displaced from their normal positions, he said, and those nearest the sun be displaced the most. In 1919 there occurred a total solar eclipse extremely favorable as to its astronomical elements, and the British Eclipse Committee, represented by astronomers Eddington and Davidson, sought to observe the Einstein phenomenon from Africa and Brazil. Unfortunately, both programs of observation were sorely afflicted by clouds and the images of only a few stars, none at all on some of the plates up to a maximum of seven stars on other plates, were recorded. Nevertheless, the measurements of the plates showed that the rays were bent from their straight-line courses in passing the sun, through angles approximately of the minute dimensions predicted by Einstein.

The William H. Crocker expedition from the Lick Observatory, University of California, represented by astronomers Campbell and Trumpler, observed the total solar eclipse of 1922 from the northwest coast of Australia, using four photographic telescopes specially designed and constructed to apply with great efficiency upon the Einstein test. The observing conditions were practically perfect. Hundreds of star images were recorded on the plates, all in excellent focus. The images of from 62 to 147 stars, on the ten plates, whose light had passed the sun at various distances were selected for measurement. The ten results from the ten plates were each in good and satisfactory accord with Einstein's prediction, and the combined results were essentially in precise accord with the predictions for the displace-

ments of the star images at their various distances, up to seven or eight degrees, from the sun.

Test No. 3: If the positions of the thousands of dark lines in the spectrum of the sun, representing the gases and vapors of the chemical elements composing the surface strata of the sun, be measured very accurately, it should be found, Einstein said, that the lines are displaced by an exceedingly small but definite amount toward the red end of the spectrum, because the strong gravitational pull of the sun upon the radiating materials at the sun's surface would affect the outgoing waves of light in such manner as to lengthen them slightly; and we know that a lengthening of the waves always shifts a spectrum toward the red end of it.

Several astronomers endeavored to observe this phenomenon, but by far the most comprehensive and successful test was that conducted by Dr. St. John, of the Mount Wilson Observatory, based upon photographs secured with the powerful tower telescopes on Mount Wilson. Although several influences in the sun are known to be capable of displacing the lines of its spectrum very slightly toward the red, yet St. John's results, after eliminating the other influences as well as possible, were in good agreement with the Einstein prediction.

A little later, through the work of Eddington and others, it became evident that the fainter component of the well-known double star Sirius, though known to be about as massive as our sun, is a surprisingly small but astonishingly dense body. A cubic inch of it, on the average, it is confidently believed, would weigh as much as 50,000 cubic inches of water. That is, a cubic inch of the star, if brought to us on the earth, would here weigh about 1,800 pounds. It was pointed out that the Einstein displacement of the lines in this star's spectrum should therefore be about twenty-seven times as great as for the lines in the sun's spectrum. Director Adams, of the Mount Wilson Observatory, using the 100-inch reflecting telescope, succeeded in the extremely difficult problem of observing this displacement, and he found it to be of the dimensions required by the Einstein theory. I may say, also, that Astronomer Moore, of the Lick Observatory, using the James Lick telescope, later succeeded in confirming Director Adams' results.

And thus did the theory of relativity meet and stand the three tests set for it by its distinguished author.

DR. MILLIKAN:

I now have the extraordinary pleasure of introducing Professor Einstein himself, but in doing so I wish to dispel a very common misconception, for the average man, who only knows science from afar, labors, I suspect, under the misunderstanding that we honor Einstein only because he was the author of the theory of relativity. Now, every physicist knows that the Nobel prize committee, which awarded him that honor in 1921, did not have to consider the theory of relativity at all in making that award. They might have given it on any one of at least four grounds, and the scientific world would have been unanimous in applauding the award on any one of them. I myself have the best of reasons for knowing which one of these four they actually chose, for the late Professor Gullstrand, the chairman of the Nobel committee, in making the 1923 award stated that it was the experimental verification of the Einstein photoelectric equation that removed all doubt as to its validity in the minds of the committee, so that they chose the first theoretical statement of that equation in 1905 by Professor Einstein as the basis of the award to him in 1921 and the experimental verification thereof as the half basis of the 1923 award. Now, this equation has nothing whatever to do with relativity, but I think that all students of modern physics will agree that it is of quite as far-reaching significance as is relativity, or, indeed, as is anything that has appeared in modern physics, for it necessitated, as soon as it was firmly established, our return to at least a semi-corpuscular theory of the nature of radiant energy. The extraordinary penetration and boldness which Einstein showed in 1905 in accepting a new group of experimental facts and following them to what seemed to him to be their inevitable consequences, whether they were reasonable or not as gauged by the conceptions prevalent at the time, has never been more strikingly demonstrated.

Any small contributions that I myself may have made to the progress of physics have been largely in the nature of experimental verification of predictions contained in three theoretical equations first set up by Einstein, and but one of these has had anything to do with relativity. The first of these was the Brownian movement equation (1905) whose verification by a number of observers removed the last doubts as to the atomic theory of matter; the second was the afore-mentioned photoelectric equation (also 1905), which changed radically our conception as to the nature of radiation; the third was the equation expressing the interconvertibility of mass and energy. This grew out of special relativity (also 1905) and it has recently predicted for me verifiable relations in the radio-active field, and it also constitutes the most important basis for the cosmic ray conclusions that I am now wishing to draw. All these three are of equal significance, I think, with the predictions from the general theory of relativity, the experimental verification of which Dr. Campbell has just described. You can throw general relativity into the waste basket, if

you will, and Professor Einstein's position as the leading mind in the development of our modern physics would still remain unchallenged. It is a very high honor to be able to introduce him to the associates to-night.

DR. EINSTEIN (*Translated by Professor William B. Munro*):

From far away I have come to you; but not to strangers. I have come among men who for many years have been true comrades with me in my labors. You, my honored Dr. Michelson, began with this work when I was only a little youngster, hardly three feet high. It was you who led the physicists into new paths, and through your marvelous experimental work paved the way for the development of the theory of relativity. You uncovered an insidious defect in the ether theory of light, as it then existed, and stimulated the ideas of H. A. Lorentz and Fitz Gerald, out of which the special theory of relativity developed. These in turn pointed the way to the general theory of relativity, and to the theory of gravitation. Without your work this theory would to-day be scarcely more than an interesting speculation; it was your verifications which first set the theory on a real basis.

Campbell's determination of the bending of rays of light coming past the sun; St. John's determination of the red shift of spectral lines due to the gravitational potential existing at the surface of the sun; Adams' determination of the red shift in the light which comes to us from the companion of Sirius—these provide the best support for the general theory of relativity.

Going beyond all this, the work of your wonderful observatory, through the recent discoveries of Hubble concerning the dependence of the red shift in the spectral lines of the spiral nebulae on their distance, has led to a dynamic conception of the spatial structure of the universe, to which Tolman's work has given an original and especially illuminating theoretical expression.

Likewise in the realm of the quantum theory I am grateful to you for important assistance because of your fundamental experimental investigations. Here I acknowledge gratefully Millikan's researches concerning the photo-electric effect, which first proved conclusively that the emission of electrons from solid bodies under the influence of light is associated with a definite period of vibration of the light itself, which result of the quantum theory is especially characteristic for the corpuscular structure of radiation.

While I let my spirit reflect upon all this, I account myself exceedingly fortunate to be able to break bread with you here in joyous mood, full of the happy conviction that your researches will continue through the future to broaden and deepen, without let or hindrance, our knowledge of nature's mysterious forces. From my heart I thank you all.

ADDRESS AT THE LUNCHEON[1]

THE presence here of hundreds of people to greet a distinguished man of science is a part of something without parallel in our American life. When newspapers everywhere continue, day after day, to give front page space to a man whose work does not directly touch the lives of the people, it signifies something unusual. The public itself would first catch the humor of a suggestion that it knows anything about relativity; and yet the warm interest in the man who has given us relativity continues.

Part of this interest is our spontaneous response to a gracious personality, full of modesty and kindness and humanity. For the rest, it means, I think, that our imagination has in some way been touched. We realize that Professor Einstein has done things on the remote frontiers of science where man seems to approach the mystery of his existence; we know that he has changed the space and time we thought a safe framework to which we might tie all our activities; that he has dared to think about the bounds of the universe itself. Those who have seen his work at first hand feel the beauty of its logical structure; others marvel that there could be any new way of thinking about stubborn old realities. And why shouldn't these things stir the imagination?

Nevertheless, Einstein himself would insist on the purely intellectual character of what he has done. He has remarked, "Relativity has nothing to do with the soul; it is a matter only for the head." But what intellectual achievement ever remained wholly detached from human feeling? The work of Copernicus was such an achievement. Yet it precipitated the bitterest of controversies because it tumbled man out from the place of honor in the center of the universe and suggested that he was of less importance than he thought. Again, the painstaking inductions of Darwin put life into the long-dormant doctrine of evolution; and you well know the emotional reactions to that intellectual effort. These are extreme instances; but even the work of Newton, which held no threat for man's cherished beliefs, profoundly influenced his outlook on life as well as his views of the physical world. And so, before such an achievement as relativity, we can not remain passive. Even though we know none of its details, we feel the freshening wind of new thought and find ourselves stirred; and we feel that it is good to be so stirred.

No one at this moment would dare predict how the

[1] Remarks on behalf of the Mount Wilson Observatory at a luncheon in honor of Professor Einstein, given by the Chamber of Commerce at Pasadena, California, February 24, 1931.

influences, direct and indirect, of Einstein's investigations are finally to be reckoned. Nevertheless, of their scientific aspect much may be said. We know that his contributions to physics in fields other than relativity would justify an award of the Nobel prize several times over, and we know the importance to both physics and astronomy of relativity itself. From these recognized accomplishments I turn to something that has received little comment.

In a sense scientific investigation is a game. The physicist must assemble his protons and electrons into a world—not any world, but one which has the properties of the physical world about us. As with all games, there are rules. Some of these are predetermined, for example, the fundamental rules of thinking. Others we choose for ourselves; and in this choice we have astonishing freedom. If I wish to arrange a shuffled pack of cards in sequences according to the four suits, you know a score of solitaire games, each with its own set of rules, by which this may be done. But it is not obvious that the game of world building may be played in more than one way. It remained for Einstein to show us that such is the case, and that if we judiciously change the rules we may still win fairly, with a greatly increased score. As a matter of fact, we have unconsciously been revising the rules of the game ever since men began to think in a scientific way; but we didn't realize it until Einstein drove it home in a way not to be ignored.

Thus with our notion of space. It may seem to you queer that space, which doubtless you think of as a great empty void, should have anything to do with rules. I don't know why it is that we so seldom point out to laymen that the space of physics and astronomy is not the void which separates objects from each other. The physicist never thinks of space apart from objects within it; in his mind is always the idea of distance—the distances of objects from each other. When he says that space has certain properties he is talking not about the empty void, but about how he makes measurements to find what these distances are. But you ask: Is he not obliged to measure distance in a definite way? The answer is, No. He may measure in any way he likes, along what we call a straight line for example; or, if he finds reason for so doing, he may measure along some curve connecting two objects and call that result the distance.

The physicist's space is therefore essentially a set of rules for measurement. Those used until Einstein suggested a change were unconsciously adopted by Euclid two thousand years ago. Until less than a century ago no one realized that by accepting one of Euclid's postulates we had committed ourselves to making measurements in a particular way, or that measurements could be made in any other way. Even then we looked upon the matter as a geometrical curiosity without practical significance; and by the time Einstein suggested the advantages of a change and we began to hear about curved space, our long-held ideas had become so fixed that readjustment was hard. For the layman it was even worse. He had in mind the empty void; and how could such a thing as a void be flat or curved? But if we say that curved space means only a new set of rules which require that measurements be made along curved lines, the idea at least makes sense, even though you may not be convinced that such a strange procedure is advantageous. But I assure you that it is, for it enables us to win the game with a score we could not otherwise attain. If that statement brings no illumination, let me ask you, What is the distance from here to New York? Your answer undoubtedly will be the miles measured over the curved surface of the earth, because that is the distance which every-day experience makes it useful to know.

As with our ideas of space, so with a dozen others. Each has been transformed and set before us in new light. Quite apart from the intrinsic importance of the results is the remarkable fact that such momentous changes of view-point could be made. By teaching us that, Einstein has put into our hands new power. The value of this service, it seems to me, can not be set too high.

And now, sir, that we must bid you farewell, let me thank you in the name of the Observatory for your friendly visit, for the companionship we have had with you, and for the inspiration your presence has brought us. We wish you Godspeed, and we hope that we may see you again soon.

FREDERICK H. SEARES
ASSISTANT DIRECTOR OF THE
MOUNT WILSON OBSERVATORY

THE REASON AND THE RESULTS OF DR. EINSTEIN'S VISIT TO THE CALIFORNIA INSTITUTE OF TECHNOLOGY

AT the time of the initiation of a strong department of physics at the California Institute in 1921 provision was made for bringing each year an outstanding European scientist to join the staff of the institute as foreign visiting professor on temporary appointment.

This professorship has been held twice by the late Dr. H. A. Lorentz, of Leiden, Holland, twice by Dr. Arnold Sommerfeld, of Munich, Germany, once by Dr. Bjerknes, of Oslo, Norway, once by Professor Raman, of India, twice by Professor Ehrenfest, of Holland; and as long as five years ago Professor Einstein, of Berlin, accepted appointment to come to Southern California to this same foreign professor-

ship but was prevented by a breakdown in his health from carrying out his plan at that time.

Three or four times since then, however, he has expressed a desire to come to the institute for purely scientific purposes, since the extensive experimental and theoretical researches being carried out both at the Norman Bridge Laboratory of Physics and the Mount Wilson Observatory were very intimately related to his own work, and a first-hand interchange of ideas was certain to be profitable to the men working in this center while an intimate view, especially of our experimental conditions and results, could scarcely fail to affect in some way Professor Einstein's own thinking.

After repeated interference, by untoward events, with the long-contemplated visit it has been made a reality this winter with results that are all that could be expected by the "Einstein collaborators" on the spot, namely, Eric T. Bell, Walter S. Adams, Richard C. Tolman, Charles E. St. John, Roy J. Kennedy, Paul S. Epstein, Harry Bateman, Edwin S. Hubble, Theodor von Karman, Albert A. Michelson, Fritz Zwicky, J. Robert Oppenheimer, Martin L. Humason, William V. Houston, Robert A. Millikan, Ira S. Bowen, Jesse W. DuMond, Linus C. Pauling, Francis G. Pease, Edward M. Thorndike, Ernest C. Watson, S. J. Barnett, Frederick H. Seares, Arthur S. King and Gustaf Stromberg. Every one of this considerable group of men who have made contributions either to some phases of the Einstein theories or to the experimental verification of these theories has been stimulated and inspired by Einstein's presence and the discussions with him that have been made possible by his stay here.

It is hoped, too, that Dr. Einstein himself has profited by the sight he has had of the extent and character of the new experimental results that have recently been brought to light by the aforementioned group of workers, and that he will feel the urge to repeat his visit, as Lorentz, Sommerfeld and Ehrenfest have done before him. His quite extraordinary human sympathy and insight, combined with his charming modesty, honesty, open-mindedness and objectivity, have made his visit an inspiration and a rich experience to all of us, whether we have been directly associated with Einstein's work or not.

ROBERT A. MILLIKAN

IT is quite impossible to estimate fully the influence of Professor Albert Einstein's visit to Pasadena and to the Mt. Wilson Observatory of the Carnegie Institution of Washington until many more years have passed.

The intangible results of the contact of this great master of science with the life and work of the observatory are likely to prove fully as important as will any of the notable lectures and discussions in which he has taken part so generously.

Among the specific problems of astronomy which Professor Einstein has considered during his visit there is none which makes so strong an appeal both to the mind and the imagination as that of the nature and structure of the universe.

In a clear and brilliant summary he has outlined the consequences of the different methods of treatment of the equations of generalized relativity and the aspects of cosmology to which they lead.

The recent discoveries of the large red-shifts in the spectra of the most distant nebulae and the enormous apparent velocities which they indicate, together with the direct relationship found to exist between distance and amount of red-shift, have modified greatly some of the earlier views.

Professor Einstein is now inclined to consider the most promising line of attack on this problem to be based on theories of a non-static universe, the general equations for which have been developed so ably by Dr. Richard Chace Tolman, of the California Institute of Technology. In the special solutions so far made involving an expanding universe the chief difficulty lies in the insufficiency of the time-scale which they require.

Of special interest to the members of the observatory staff have been Professor Einstein's outline of the method and development of the unified field theory; his suggestive discussion of the possible origin of circulatory movements in the solar atmosphere and their bearing on the rotation of the sun and the formation of sun-spots, and the valuable insight he has given us into his interpretation of some of the equations governing the probability of transitions within the atom, a field of vast importance in spectroscopy and one with which his name is associated most intimately.

His insistence upon the necessity and importance of the results of observation to control theoretical assumptions and developments has been a striking characteristic of his mode of thought.

Beyond any other consideration, however, has been the opportunity of observing his keen and brilliant mind at work, its instant grasp of the essentials of a problem and its extraordinary resourcefulness in its solution.

Finally, no one can meet Professor Einstein even for the first time without an immediate realization of extraordinary intellectual power combined with a natural simplicity and kindliness which so often characterize great genius.

WALTER S. ADAMS

OBITUARY

JAMES PERRIN SMITH

DR. JAMES PERRIN SMITH, professor emeritus of paleontology at Stanford University, died suddenly at his home in Palo Alto, California, January 1, 1931.

Dr. Smith was born at the home place on Saluda River, near Cokesbury, Abbeyville County, South Carolina, November 27, 1864. He was the son of the Reverend James Francis and Julia (Forster) Smith. His parents were highly cultured, and realizing the value of an education they were anxious that their children should have every opportunity possible of securing a thorough one. The public schools in the vicinity of Cokesbury were very poor, and on account of this James Perrin was taught at home. His parents moved to Spartanburg, South Carolina, while he was still quite young, so that he might have the advantages of the schools there. He entered the preparatory school of Wofford College and from 1876 to 1879 was under the tutorship of Charles Forster Smith, an elder brother. In the fall of 1880 he entered Wofford College and in 1884 was graduated with the A.B. degree. He then entered Vanderbilt University, where he was a student from 1884 to 1887, receiving the M.A. degree in 1886.

Following his work at Vanderbilt he taught for two years in the Nashville, Tennessee, high school. In 1888 Smith was appointed assistant chemist and geologist for the Arkansas Geological Survey, which had been but recently organized.

At that time it was the custom to go to Germany for advanced scientific work, and so Smith entered the University of Göttingen to study paleontology under Professor von Koenen and mineralogy under Professor Liebisch. He received the degree of doctor of philosophy in paleontology in 1892. In the spring of 1892 he spent a short time in Munich under the instruction of Professor von Zittel. During his two years at Göttingen Dr. Smith was devoting all his spare time to the study of the ammonites, a group in which he had become very much interested. Having finished his work at Göttingen he returned to the United States.

Stanford University had opened in the fall of 1891, and Dr. John Casper Branner had been appointed head of the department of geology. In 1892 he selected Dr. Smith as his associate, with the title of professor of paleontology and mineralogy. For a number of years Dr. Smith gave courses in historical geology, paleontology, mineralogy, crystallography and petrography. In 1905, however, he was made professor of paleontology and was relieved of his work in mineralogy, crystallography and petrography. On taking up his work at Stanford Dr. Smith continued his study of the ammonites, making collecting trips and studying the stratigraphy of various parts of the western United States.

He also became interested in California geology and in time was regarded as an authority on the subject. In 1916 he supervised the compilation of a geological map of California and to accompany it prepared a report descriptive of the geologic formations of the state. These were published by the California State Mining Bureau.

The writer has known Dr. Smith for the past thirty-five years, first as a teacher in the classroom and in the field and later as a very personal friend and associate. As a teacher he was held in the very highest regard by all his students and associates. He had the faculty of getting from each one the very best results that were possible. He was first and always a teacher. Other monuments may be erected in his honor, but his chief monument will be the affectionate memory of the students who during his thirty-seven years of teaching profited by his instruction and association. The influence of Dr. Smith on his students was by no means confined to the class room. In fact, his habit of meeting students in groups in front of the Geology building and telling stories and discussing various problems with them has had a very marked influence on the lives of many persons. He was never too busy to listen to students when they had real problems to discuss with him and they were sure of a sympathetic audience and good sound advice.

The very deep regard in which Dr. Smith was held by his former students was shown when, on his retirement as executive head of the geology department at Stanford University in 1922, the graduates of the department presented him with ten thousand dollars. This was one of the most unusual tributes ever paid to any teacher.

Dr. Smith had a very high standing as a scientist and while his specialty was invertebrate paleontology, at the same time he had a thorough knowledge of the other phases of geology. He early became interested in the ammonites and devoted his whole life to a study of this group of fossils and was recognized internationally as an authority on it. He was especially interested in working out the evolutionary stages of the various forms and in studying them from a biological as well as geological standpoint.

From 1895 to 1906 Dr. Smith held the title of assistant geologist on the U. S. Geological Survey and from 1906 to 1924 the title of geologist. In this partial relation he devoted his spare time from university duties to the collecting and study of ammon-

ites. From this there resulted a notable series of publications. In 1902 his paper on the "Carboniferous Ammonoids of America," 205 pages and 29 plates, was published by the U. S. Geological Survey as Monograph 42. This was followed in 1905 by his paper, with Alpheus Hyatt, entitled "Triassic Cephalopod Genera of America," U. S. Geological Survey Professional Paper 40. It contained 394 pages and 85 plates. In 1914 his paper, "Middle Triassic Marine Invertebrate Faunas of North America," appeared as Professional Paper 83, U. S. Geological Survey, 254 pages and 99 plates, and in 1927 "The Upper Triassic Marine Invertebrate Faunas of North America" was published by the U. S. Geological Survey as Professional Paper 141, with 363 pages and 121 plates. Still another paper, "The Lower Triassic Ammonoids of North America," was completed at the time of his death and will be published by the U. S. Geological Survey.

While the above are Dr. Smith's largest papers and perhaps the most important ones, he published more than fifty others. The high character of his scientific work was recognized by the best scientists of the country when in 1925 he was elected to membership in the National Academy of Sciences and on April 24, 1928, was awarded the Mary Clark Thompson Gold Medal for his research in geology and paleontology.

Dr. Smith was married August 19, 1896, to Miss Frances Norris Rand, of Manitowoc, Wisconsin. They had four children, Mary, Forster, Howard and Charles. The daughter and two sons have graduated from Stanford, and the youngest is still in the university.

In addition to his other work Dr. Smith served on various university committees and in many ways was a very important influence not only in determining the policy of the geology department but of the university as a whole. He belonged to but few scientific societies. He was, however, a very loyal member of the Le Conte Club and attended practically all the meetings. He was much interested in sports of various kinds and as a college student was pitcher for his college baseball team. In later years he became very fond of fishing as a diversion in summer vacations.

Dr. Smith was one of the most kind and lovable men it has ever been my privilege to know. He was uniformly courteous, exceedingly modest and unassuming and possessed the very highest sense of honor. This last was well shown in his scientific work, where he insisted full credit should be given each one for any work done. He gave very freely, however, of his own material to his advanced students.

While we mourn deeply his loss we have the very great satisfaction of having had the privilege of knowing him and of being associated with him for so many years.

SOLON SHEDD

STANFORD UNIVERSITY

RECENT DEATHS

DR. ALBERT PAUL WEISS, professor of psychology at the Ohio State University, died on April 3, at the age of fifty-one years.

DR. OTTO WALLACH, emeritus professor of chemistry in the University of Bonn, died on March 1, at the age of eighty-four years. Dr. Wallach was awarded a Nobel prize in 1910 for his work on terpenes.

THE death is announced of Dr. Johannes Reinke, professor of botany at Kiel.

PROFESSOR D. HEPBURN, of the department of anatomy of the Cardiff Medical School, University of Wales, died on March 10, at the age of seventy-two years.

Nature reports the death of Henry Harries, long connected with the British Meteorological Office, on February 8, at the age of seventy-nine years, and of Professor Carl Emil Hansen Ostenfeld, professor of botany and director of the botanical garden in the University of Copenhagen, on January 16, aged fifty-eight years.

SCIENTIFIC EVENTS

GEOPHYSICAL SURVEYS

A SPECIAL exhibition of apparatus and equipment used in geophysical surveys has been opened in the Science Museum, South Kensington. The exhibits, as described in the London *Times*, have been specially selected to illustrate the development of all the important methods used to locate mineral deposits by the use of sensitive physical apparatus, and the display, though preceded by a smaller exhibition in Stockholm last year, is the first attempt to assemble on a large scale instruments up to the most modern examples. Details of field operations and the technique of the various methods are illustrated by photographs and diagrams, and examples are shown in maps and large scale plans of the results obtained by geophysical surveys in various parts of the world.

The exhibition begins by illustrating general magnetic principles, through specimens of William Gilbert's "terrella" or circular loadstone of date about 1600, specimens of which are lent by the Royal Society. The sixteenth-century sundial compass, and the wooden-bowled mariner's compass of the mid-sev-

enteenth century are shown for comparison with the Chinese geomancer's compass, and the various forms of dip circle which show the natural inclination of the compass needle. The magnetic compass was used in special forms of design for mining purposes from the middle of the seventeenth century, and it is fairly easy to understand the working of examples lent from Sweden, but the instruments become increasingly complicated as the visitor proceeds, though the "Watts Vertical Variometer," a new type of British instrument evolved in the present year, is neatly and comprehensibly made.

A second method relies upon the gravitational effect exercised by bodies proportionally to their mass, and its practical application to prospecting dates only from 1888, when the Eötvös torsion balance was invented. Progress with instruments involving this method has been particularly rapid in the past five years, and a novel form of apparatus designed by Captain H. Shaw and Mr. E. Lancaster-Jones, two members of the staff of the Science Museum, has recently come into use.

Another section of the exhibition shows the seismic method of investigation, which consists in testing the rate at which a small artificial earthquake (usually an explosion) is propagated over various points, the elasticity of the local crust of the earth being discovered by these means, while the fourth method, that of testing electrical interference by mineral bodies, is shown in a separate range of instruments.

CUSTOMS DUTIES ON SCIENTIFIC APPARATUS

THE imposition of the appropriate customs duties upon scientific apparatus imported into the United States by the University of Illinois, a state agency, through the port of Chicago, is reported by the *United States Daily* to have been upheld by Justice George M. Young, of the United States Customs Court.

Protest was lodged against this assessment of duty upon the following ground:

> That such merchandise should come in without duty, as being imported by an instrumentality of the Government of the State of Illinois, for use in the execution of a government function and purpose, under the well-established policy of the Federal Government not to tax the states or their agencies and subdivisions.

At the trial it was argued that the Federal Government has no authority to impose duty upon imports made by the State of Illinois.

The attorney for the University of Illinois, Mr. Sveinbjorn Johnson, contended that the exaction complained of is a tax; that the property upon which it is sought to be levied is property used necessarily and exclusively by the University of Illinois as an educational agency; that the university is a state agency, and that education is a governmental function, so that the agencies and properties, used in connection therewith, are exempt from federal taxation as instrumentalities of the state created and used to facilitate the exercise of a governmental as distinguished from a proprietary purpose.

In his opinion, upholding the imposition of the tariff assessment, Judge Young stated:

> If this and similar tariff taxes on goods imported by a state university were raised so high as to prohibit the articles from importation, would that destroy the institution, assuming that it is a governmental instrumentality of the state? If it would, then the tariff is invalid. If not, then it is constitutional.
>
> Counsel for the plaintiff contends that the power to levy such a tax is the power to prevent its use by the consumer. We admit that this is true, but if the University of Illinois were prevented entirely from making importations, would it be destroyed? We believe not.
>
> The existence of the states is in no way threatened by such duties. Even if the duties should be made so high as to preclude their importation, it would not result in destroying the university or seriously impairing its usefulness.
>
> The constitutional implication preventing the Federal Government and the state from taxing each other's agencies must receive a practical construction permitting each government to function with a minimum of interference with the other.
>
> We therefore hold that the plaintiff herein, the University of Illinois, has no constitutional exemption from the payment of duties collected in the case at bar.
>
> The defendant (the Federal Government) is entitled to judgment.

THE SINNOTT MEMORIAL IN THE CRATER LAKE NATIONAL PARK

VISITORS to Crater Lake National Park, Oregon, next summer will benefit from the recent action of the Carnegie Corporation in donating $5,000 for the furnishing and installation of equipment in the Sinnott Memorial located there.

This structure, authorized by Congress last year in connection with appropriations for the National Park Service, is a memorial to Representative Nicholas J. Sinnott, of Oregon, who took a keen interest in the park and did much to further its use by the public. In providing for the memorial Congress appropriated $10,000 for its construction, acting upon the suggestion of the Honorable Louis C. Cramton, then chairman of the subcommittee of the House Appropriations Committee handling Interior Department appropriations.

The Carnegie fund for the development of the memorial has been transmitted through the National

Academy of Sciences, which has appointed a committee to cooperate with the National Park Service in the installation of equipment. Dr. John C. Merriam, president of the Carnegie Institution, is chairman of this committee. The other members are Dr. Frederick Whiting, president of the Art Federation; Dr. David White, National Academy of Sciences; Dr. Fred Wright, of the Geophysical Laboratory; and Mr. Charles W. Eliot, 2nd, of the National Parks and Planning Commission. It is also hoped that Mr. Frederick Law Olmsted, nationally known landscape architect, may accept appointment to the committee. Development of the museum will proceed under the supervision of Ansel F. Hall, senior park naturalist of the National Park Service, who while in Washington recently conferred with this committee.

The memorial will be developed with a twofold purpose: To bring to the visitor to the park an adequate idea of the beauty of the picture presented, and to furnish interesting scientific data as to the formation of the crater in which the blue lake lies and its geologic history.

A DIVISION OF PLANT PATHOLOGY AT THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH

DR. LOUIS O. KUNKEL, at present pathologist at the Boyce Thompson Institute for Plant Research at Yonkers, New York, has been appointed a member of the Rockefeller Institute for Medical Research in charge of a division of plant pathology, to be established in connection with its Department of Animal Pathology situated near Princeton, New Jersey. The combined laboratories will hereafter be known as the Department of Animal and Plant Pathology of the Rockefeller Institute. The department is located on a tract of approximately eight hundred acres of land at Plainsboro, New Jersey, three miles from Princeton University. With the addition of plant pathology to the subjects studied in its group of laboratories and hospital, the Rockefeller Institute will include in its scientific work all the main branches of the pathology of living matter. For the first time human pathology, the pathology of lower animals and that of plants will have been brought together into one closely knit investigative unit.

Dr. Kunkel was born in Audrain County, Missouri, on May 7, 1884, and studied and received degrees at the University of Missouri, Washington University, St. Louis, and Columbia University. He was Cutting Traveling Fellow of Columbia University during 1915–16, when he studied in Stockholm, Sweden, and in Freiburg, Germany. He taught at the University of Missouri and at Columbia University, and later became pathologist to the Bureau of Plant Industry in the U. S. Department of Agriculture, then associate pathologist with the Hawaiian Sugar Planters' Association, and in 1923 pathologist at the Boyce Thompson Institute for Plant Research.

Dr. Kunkel has been a contributor to the pathology of plant diseases, and his most recent investigations relate to the virus diseases of certain economic and ornamental plants. He has made contributions to the knowledge of the mosaic diseases of tobacco, sugar cane and corn, and of the virus disease of asters known as "yellows."

The constantly increasing number of diseases of man and lower animals discovered to be induced by filter-passing viruses brings the pathology of animal and plant diseases into intimate association. That both animal and plant pathology will profit materially by being investigated in close relationship may be taken as assured.

Dr. Kunkel will spend a period abroad, visiting institutions in which the study of plant pathology is pursued, before designing the new laboratories and establishing the new division of the Rockefeller Institute at Princeton.

CONFERENCE ON THE PROMOTION OF INTEREST IN PHYSICS

THE Council of the American Physical Society is considering how best to promote interest in all branches of physics and realizes that already existing organizations of students, teachers and users of physics may, in many places, be the best agencies for this purpose. In order to cooperate properly with these organizations and in order to assist if called upon in the formation of new groups, the society invites all who are interested to attend a conference for the informal discussion of some of the questions that have already presented themselves. The most pressing of these are:

1. Should the American Physical Society, or any larger organization, publish a journal of general interest to physicists? If so, what should it contain and how frequently should it appear?

2. Should the American Physical Society assist local organizations in arranging for programs of special interest, as, for example, by supplying lecturers?

3. How should the cost of desirable additional activities be met?

Other questions appropriate to the general purpose of the conference will be discussed if time permits.

The conference will be held at 8:00 p. m. on Thursday, April 30, in the National Academy of Sciences Building, B and 21st Streets, Washington, D. C. Professor L. W. McKeehan, Yale University, chairman of the American Physical Society's committee on sections and local groups, will be glad to

receive, as soon as possible, information or suggestions for presentation by those unable to attend in person.

BIRTHDAYS AND RESEARCH CENTERS

UNDER this title *Nature* is publishing each week under the birthdays of scientific men occurring during the week autobiographical notes on the work that they are doing. The four statements in the issue of March 21 include the following:

March 22, 1868—PROFESSOR ROBERT A. MILLIKAN, chairman of the executive council of the California Institute of Technology and director of the Norman Bridge Laboratory.

I am still pursuing quite intensively my studies in the field of the cosmic radiations; for they have relations to meteorology not yet fully explored, and their values at very high altitudes still have something to teach us about the precise nature of the cosmic atom-building processes. Also, as an adjunct to these studies, I am interested in the problem of the origin of the very heavy elements and, as a possible clue to its solution, am collecting further data, by a new method, on the terrestrial distribution of the radioactive elements. Artificially stimulated radiations of high penetrating power are also a part of the program.

March 25, 1863—DR. SIMON FLEXNER, For. Mem. R.S., director of the Rockefeller Institute for Medical Research.

The constantly growing number of those diseases of man, the lower animals and plants shown to be brought about by filterable agents or viruses, emphasizes their known significance. Among human beings, a disease of this character is poliomyelitis or infantile paralysis. The modes of infection and of extension of the virus of this disease are questions of outstanding importance. Ever since 1909, when the first serial transmission of the disease to monkeys was accomplished (Flexner and Lewis), these questions have commanded attention. The indications, then secured and since confirmed, are to the effect that the virus is nerve conducted, as it enters and even as it leaves the body of infected human beings and animals *via* the respiratory mucous membranes.

Not only is this finding of importance in so serious a disease as poliomyelitis, but corresponding questions are of high interest in connection with virus diseases generally, as is also the question of the precise nature (chemical or otherwise) of the viruses themselves.

SCIENTIFIC NOTES AND NEWS

ACCORDING to press dispatches Professor Albert A. Michelson has improved after a somewhat critical nervous collapse. Dr. Michelson has been carrying on his experiments in the vicinity of Pasadena, measuring the velocity of light in a vacuum tube. It is said that he has been working until after midnight, returning from the Irvine Ranch, near Santa Ana, at three o'clock in the morning. The experiments are being continued during Dr. Michelson's illness by his assistants, Dr. Francis G. Pease, of the Mount Wilson Observatory, and Dr. Fred Pearson, of the University of Chicago.

PROFESSOR G. H. PARKER, director of the Harvard Zoological Laboratory, has been elected an honorary member of the Philosophical Society of Cambridge, England.

M. ELIE CARTAN, professor of mathematics at the University of Paris, has been elected a member of the Paris Academy of Sciences to succeed the late Paul Appell.

DR. PHILIP FURTWÄNGLER, professor of mathematics at the University of Vienna, has been elected a member of the Prussian Academy of Sciences.

THE University of Edinburgh will confer the honorary degree of doctor of laws at the graduation ceremonial on July 2 on: Dr. E. J. Allen, director of the Marine Biological Laboratory, Plymouth; on Sir George Berry, member of Parliament for the Scottish universities, formerly lecturer in ophthalmology in the University of Edinburgh, and on Sir Walter Morley Fletcher, secretary of the Medical Research Council.

AT a meeting of the senate of the University of London, Sir John Rose Bradford, president of the Royal College of Physicians, was nominated to receive the honorary degree of doctor of medicine, and Professor Kappers, of Amsterdam, the degree of doctor of science.

THE University of Darmstadt has conferred the honorary degree of doctor of engineering upon Bernard Arthur Behrend, of Wellesley Hills, Massachusetts, "for meritorious work in the construction of induction machines."

SIX chemists received the honorary doctorate of laws in connection with the dedication exercises of the building for chemistry, erected at a cost of $500,000, at Indiana University. These were: Dr. Fuanobu Isobe, chemical engineer of Tokio, Japan; Dr. O. C. Martin, chemical and metallurgical engineer, Antwerp; Dr. L. F. Rettger, chemist and bacteriologist, Yale University; Dr. O. B. Perry, consulting mining engineer, San Francisco; Dr. Earl Blough, chemical and metallurgical engineer, New York City; Dr. J. N. Currie, zymochemical engineer,

Brooklyn, New York. All are graduates of Indiana University.

IN appreciation of the work accomplished in the Czechoslovakian Republic and of his contributions to agricultural science, Dean C. B. Hutchison, of the University of California College of Agriculture, has been decorated with the Order of the White Lion. The decoration was bestowed by Dr. K. Brejske, Czechoslovakian consul in San Francisco.

THE American Geographical Society announces the award of the Charles P. Daly Medal for 1931 to Major Gunnar Isachsen, director of the Maritime Museum, Oslo, for his contributions to our knowledge of the Polar regions. Major Isachsen was topographer on the second Norwegian Arctic Expedition in the *Fram* under Otto Sverdrup (1898–1902) when important discoveries were made in the Canadian Arctic Archipelago. During 1906–1910 he spent four summers in Spitsbergen. Major Isachsen visited the Antarctic in 1926–1927 for study of the Norwegian whaling industry, an account of which he presented in the July, 1929, number of *The Geographical Review*. This last season, 1930–31, he commanded the *Norvegia* on her circumnavigation of the Antarctic, Consul Lars Christensen's project for study of the number and distribution of whales.

THE Duddell Medal of the Physical Society of London, awarded for the advancement of knowledge by the invention or design of scientific instruments or by the discovery of materials used in their construction, has been given to Sir Ambrose Fleming, and was presented to him by the president, Professor Sir Arthur Eddington, at the annual general meeting of the Physical Society, which was held on March 20. The connection of Sir Ambrose Fleming with the Physical Society of London dates back to its beginning, for he read the first paper at the inaugural meeting of the society in March, 1874.

THE council of the Royal Society, as *Nature* records, has agreed to recommend for election as fellows of the society the following seventeen candidates: Percy George Hamnall Boswell, professor of geology in the Imperial College of Science and Technology; Alfred Joseph Clark, professor of pharmacology in the University of Edinburgh; Charles Davidson, assistant at the Royal Observatory, Greenwich; Reginald Ruggles Gates, professor of botany, King's College, London; Charles Stanley Gibson, professor of chemistry, Guy's Hospital Medical School; Hermann Glauert, principal scientific officer, Royal Aircraft Establishment, Farnborough; Charles Robert Harington, reader in pathological chemistry in the University of London; Isidor Morris Heilbron, professor of organic chemistry in the University of Liverpool; Sir Alexander Cruikshank Houston, director of water examinations to the Metropolitan Water Board; Lieutenant-Colonel Sydney Price James, adviser on tropical diseases to the British Ministry of Health; Charles Frewen Jenkin, lately professor of engineering science in the University of Oxford; Stanley Wells Kemp, director of research, *Discovery* Expedition; Thomas Howell Laby, professor of natural philosophy, University of Melbourne; William Kingdon Spencer, paleontologist; Edward Charles Titchmarsh, professor of pure mathematics, the University of Liverpool; Wilfred Trotter, surgeon to University College Hospital; Miles Walker, professor of electrical engineering, University of Manchester.

PROFESSOR E. J. GARWOOD has been elected president of the Geological Society of London. The vice-presidents are Mr. J. F. N. Green, Professor J. W. Gregory, Dr. H. H. Thomas and Professor W. W. Watts.

DR. CHARLES L. CHRISTENSEN, the newly elected dean of the College of Agriculture of the University of Wisconsin, has taken up his work at the university, after closing up his affairs as secretary of the Federal Farm Board.

MR. H. J. SPELMAN, chief engineer of the West Virginia State Road Commission, has resigned to take a position with the U. S. Bureau of Roads in Washington.

DR. BRADFORD WILLARD has been appointed a correspondent of the *Revue de Géologie* for the Pennsylvania Topographic and Geologic Survey.

MR. A. L. COLTON, for the last seven years on the editorial staff of the Bureau of Entomology, retired in February. Mr. Colton formerly served as assistant astronomer at the Lick Observatory and taught physics at the University of Wisconsin.

MR. WILLIAM R. BARBOUR, formerly in tropical forestry work in Haiti and other Caribbean countries, has been detailed by the Forest Service to organize a forestry program for the Virgin Islands. He has reported for work at St. Thomas and has begun a survey of forest conditions on the islands.

DR. E. V. MCCOLLUM, professor of biochemistry at the Johns Hopkins University, has been appointed by the Secretary of Agriculture as delegate to the International Dairy Congress in Copenhagen.

DR. LOUIS T. MORE, professor of physics and dean of the Graduate School of the University of Cincinnati, sailed on April 4 for Europe with his brother, Dr. Paul Elmer More, professor of philosophy at Princeton University.

PROFESSOR K. F. WENCKEBACH, of the University of Vienna, has been invited by the Queen Wilhelmina Jubilee Foundation to investigate the pathology of the heart in acute beri-beri at the recently established medical faculty at Batavia in Java.

DR. ARNO B. LUCKHARDT, of the University of Chicago, delivered a lecture at Ohio University on "Highlights and Shadows in the History of Anesthesia" on March 11. This lecture was the second of a series given under the auspices of the department of biology. The first lecture was given by Dr. Lawrence H. Snyder, of the Ohio State University, on "Clinical and Legal Aspects of Blood Groups."

SIR WILLIAM HARDY, of the Food Investigation Board of the Department of Scientific and Industrial Research and Low Temperature Research Station, Cambridge, England, will deliver the seventh Harvey Society Lecture at the New York Academy of Medicine, on Thursday, April 16. His subject will be "The Use of Cold in the Analysis of Physiological Function."

DR. B. M. DUGGAR, professor of plant physiology in the University of Wisconsin, will give the invitation address in connection with the annual initiation of the Iowa Chapter of Sigma Xi on April 29.

DR. MAURICE A. BIGELOW, professor of biology at Teachers College, Columbia University, and chairman of the executive committee of the American Social Hygiene Association, will deliver a lecture entitled "Social Hygiene and the Family" in London, on April 21, under the auspices of the British Social Hygiene Council. The Duchess of Atholl, M.P., will preside.

IN the issue of SCIENCE for March 27, the name of the president of the Columbia Chapter of Sigma Xi was incorrectly given. It should have been given as Professor Jerome J. Morgan.

THE first scientific meeting of the recently founded German Society for Internal Medicine and Neurology in the Czechoslovakian Republic was held at Prague on March 7 and 8, when the chief subject for discussion was the modern treatment of blood diseases.

THE Second International Congress of the History of Science and Technology will take place in London from Monday, June 29, to Friday, July 3, 1931. The headquarters will be the Science Museum, South Kensington. The congress, which originated with the Comité International d'Histoire des Sciences, founded at Oslo on August 17, 1928, meets annually in Paris and organizes every three years a congress in which those interested in the history of science and technology are invited to take part. For the coming congress the Comité has been fortunate in enlisting the cooperation of its parent body, the Comité International des Sciences Historiques, together with that of two other international societies—the History of Science Society and the Newcomen Society for the Study of the History of Engineering and Technology. The aim of the congress is to provide opportunity for intercourse and exchange of thought between all those who are interested in the various departments of the History of Science and Technology. The program is being arranged to cover the period indicated. Besides scientific communications, there will be social gatherings, visits to institutions and excursions to places of historic interest. Further particulars can be obtained on application to The Hon. Sec. International Congress of the History of Science, The Science Museum, South Kensington, London S. W. 7, England.

THE fifty-ninth convention of the Electrochemical Society will be held at Birmingham, Alabama, on April 23, 24 and 25. The three main sessions will be devoted to "Ceramics," "Electronics" and "The Electrodeposition of the Noble Metals," respectively. Birmingham is rapidly developing into one of the most important industrial centers of the United States, and members and guests of the society will have ample opportunity to visit a number of the leading industrial plants of the South.

THE eighth annual meeting of the West Virginia Academy of Science will be held at the West Virginia Wesleyan College, Buckhannon, West Virginia, on April 24 and 25. Sectional meetings will be held on Friday afternoon following the address of President A. B. Brooks, of Oglebay Park, Wheeling. A banquet will be held on Friday evening, after which Professor Roy Dorcus, of the Johns Hopkins University, will deliver the principal address. Saturday morning will be devoted to excursions to near-by points of interest.

THE Alabama Academy of Science held its eighth annual meeting on the campus of the University of Alabama on March 13 and 14. More than fifty papers were read and discussed. At a banquet attended by more than a hundred, President Emmett B. Carmichael read a paper on "The South's Contribution to Science." The visiting speaker was Dr. E. E. Reinke, head of the department of biology of Vanderbilt University, who discussed "The Highlands (North Carolina) Museum and Biological Laboratory Plans for a Mountain Research Station in the South." Officers elected for the year 1931–32 are: *President,* George Fertig, director of the Pittsburgh Testing Laboratories, Birmingham; *First Vice-president,* Herbert Martin, professor of chemistry, Auburn; *Second Vice-president,* H. C. Heath, professor of biology,

Woman's College, Montgomery; *Treasurer,* E. A. Hawk, fuel engineer, T. C. I., Ensley; *Editor of the Journal,* E. V. Jones, professor of chemistry, Birmingham-Southern College; *Councillor to the American Association for the Advancement of Science,* Emmett B. Carmichael, professor of biochemistry, University of Alabama; *Permanent Secretary,* J. L. Brakefield, professor of biology, Howard College, Birmingham. The academy will hold its ninth annual meeting in March 1932 at Howard College, Birmingham.

THE College of Medicine of the University of Illinois Chapter of Sigma Xi has announced the elections to the chapter for the year. There are three promotions from associate to active membership, eighteen elections to active, and twenty-two to associate membership. Of the forty elections to membership, twenty-one are faculty members, including two from the College of Dentistry and one from the College of Pharmacy. The balance of the elections are from the student body of the Graduate School, which numbers one hundred and twenty-one in graduate work in medicine and dentistry. The chapter has recently established an annual cash prize for the best original investigation by a student of the College of Medicine, Dentistry or the Graduate School. The chapter is unique in that it is the only one that has been granted so far to a college of medicine and is the second chapter granted to the University of Illinois. The only other chapter of the society in somewhat similar position is the chapter at the Mayo Foundation, which is the second chapter in the University of Minnesota. The officers of the chapter are: Dr. William F. Petersen, *President;* Dr. W. J. R. Camp, *Vice-president;* Dr. William H. Welker, *Secretary;* Dr. I. Pilot, *Treasurer; Executive Committee,* Dr. D. J. Davis, Dr. O. F. Kampmeier and Dr. H. A. McGuigan.

THE Louisiana Academy of Sciences, presided over by Professor F. G. Fournet, vice-chairman; the Louisiana-Mississippi Section of the Mathematical Association of America, presided over by Professor Irby C. Nichols, of Louisiana State University, chairman, and the Louisiana-Mississippi branch of the National Council of Teachers of Mathematics, under the presidency of Professor B. A. Tucker, held a joint meeting at the Louisiana State Normal College at Natchitoches on March 13. In addition to the technical papers presented at the scientific sessions an illustrated lecture on "The Great Cities of Ancient America" was given by Dr. Frans Blom, of the department of Middle American Research, Tulane University. The local branch of the American Association of University Women served tea to members of the societies and their guests, and the meeting closed with a banquet in the college dining hall.

THE *Journal* of the New York Botanical Garden reports that Dr. E. D. Merrill has recently presented to the library of the garden two Wedgewood medallions, one of Sir William Jackson Hooker, director of the Royal Botanic Garden at Kew from 1841 to 1865, and the other of his son, Sir Joseph Dalton Hooker, who was director from 1865 to 1885. These medallions were prepared from the original dies of earlier date in connection with the Fifth International Botanical Congress held at Cambridge, England, last August, at which Dr. Merrill was one of the five delegates representing the New York Botanical Garden. The various excursions arranged for visiting delegates before, during and after the congress included a pilgrimage to Halesworth Church, in Suffolk, for the dedication of a memorial tablet to Sir Joseph Hooker, born at Halesworth, and Sir William, who lived there for a number of years.

THE University of Wisconsin was recently made the beneficiary of $20,000 in the will of the late Mrs. Janet Van Hise, widow of Professor Charles R. Van Hise, formerly president of the university. The money will provide a research fellowship in the field of geology.

SIR WILLIAM BRAGG, director of the Royal Institution and of the Davy-Faraday Research Laboratory, spoke at a luncheon of the British Electrical Development Association at the Savoy Hotel on March 20, on the celebration of the Faraday Centenary in September. According to the report in the London *Times,* the guests numbered over five hundred and included visitors from France, Germany, Holland, Belgium and Austria. The president, Alderman E. Huntsman, presided. The chief feature of the Faraday celebrations, Sir W. Bragg said, "would be an exhibition in the Albert Hall illustrating the nature of Faraday's discoveries and the lessons to be derived from them. A statue of Faraday would be the center of the exhibition. At his feet one of his first experiments would be shown and the actual things be used—a piece of wire, a magnet and a drop of mercury. From this would spread, like the spokes of a wheel from its center, numerous exhibits showing the marvelous development of the uses of electricity in varied forms from that simple experiment. As Faraday by the charm and skill of his lectures had inspired his listeners with the beauty and uses of his discoveries, so the association must be at pains to cultivate the art of exposition. The British electrical industry ought to afford the greatest encouragement to the country. What our men had done in the past our men could do in the future."

DISCUSSION

A UNIFORM SCHEME FOR CITATIONS[1]

THE desirability of a standard scheme for footnote and other references to literature has been frequently set forth and is obvious to any one who has much contact with the 57 varieties now to be found. One of the government bibliographers writes:

> Bibliographical material at best is hard to read, and we believe that in order to fulfill its purpose it should be printed with the comfort and convenience of the reader in mind.

The difficulty would of course be lessened by a uniform scheme. Such a scheme, based on experience with thousands of citations, has been in use for many years in the publications of the U. S. Geological Survey and has proved entirely satisfactory. It can be exhibited best by sample citations of the two major classes:

1 (for an article or paper contained in a serial publication): Brewer, W. H., On the age of the gold-bearing rocks of the Pacific coast: Am. Jour. Sci., 2d ser., vol. 42, pp. 114–118, 1866.

2 (for an independent paper or book—that is, one not contained in a serial publication): Wright, W. B., The Quaternary ice age, 2d ed., p. 374, 1916.

If the place of publication and publisher's name seem necessary or desirable for more certain identification they are inserted just before the date.

The outstanding features of this scheme are the punctuation, the use (not omission) of the forms "ser.," "vol.," "pp.," etc., and the use of ordinary roman type throughout.

The punctuation keeps each citation together as a unit, the items being separated only by commas except that a colon is used to separate the title of an article in a serial publication from the title of the publication. If more than one paper by the same author is cited in a single reference a semicolon is used to separate the citations:

> Bouyoucos, G. J., Estimation of the colloidal material in soils: Science, new ser., vol. 64, p. 362, 1926; A rapid method for mechanical analysis of soils: Idem, vol. 65, pp. 549–551, 1927.

Some styles use a period after the author's name, after the title of the article, and before the date, each period followed by the same amount of space that is used between sentences in text. This breaks up the citation unnecessarily and is especially undesirable where more than one work is cited in a single reference. For example, one footnote in a recent Geological Survey publication contained references to four papers by three sets of joint authors—one paper each by two sets and two papers by the third set. In this footnote periods and sentence spaces were used only in two places—to separate the references to the different sets of authors. In the style just indicated it would have been broken up by thirteen periods and sentence spaces. Other styles use a colon after the author's name. This seems unnecessary, as a comma is adequate punctuation; moreover, the colon is needed in the place indicated above—between the title and the serial designation.

The scheme of omitting the forms "ser.," "vol.," "pp.," etc., and using parentheses for series number, black face for volume number, and colon preceding page numbers effects a small saving in space but is objectionable in every other respect. Its meaning is not clearly evident without an explanation, and it falls down in a citation that must include reference to a number (or part, Heft, Teil, etc.), as well as a series and a volume. With the abbreviated forms for these designations any one of average intelligence can understand a citation at a glance; without them even a reader familiar with the scheme is likely to be halted a few seconds in taking in the meaning. The government bibliographer already quoted says: "Too great emphasis on space saving may defeat the purpose of such compilations." Even the slight saving in space may not mean a saving in cost of printing, as some printers make an extra charge for composition in which black face type is used in combination with roman. Professor W. M. Davis, in a recent contribution to SCIENCE, states that it seems unnecessary to give the series number, as the date is sufficient to identify the series cited. If this is a valid argument the volume number might also be omitted in most citations. Certainly a publication issued in series, each series starting with volume 1, is not adequately cited if the series number is omitted. For example, the *American Journal of Science* is now in its fifth series and has had five volumes numbered 12. To compel the reader to identify the particular volume 12 by means of the date is shifting to him part of the author's burden. The need of omitting the series number disappears if the forms "ser.," etc. are used. In German citations in Geological Survey style the forms "Band," "Heft," "Hälfte," "Teil," "Abt." (for Abteilung), and "Lief." (for Lieferung) are retained for the sake of certain identification, but "p." or "pp." is used instead of "S." (Seite). In citations from other languages the English forms "vol." and "pt." (for part) are generally clear enough.

[1] Published by permission of the acting director, U. S. Geological Survey.

If a volume of a serial is paged continuously it is not necessary to cite the particular number. In "vol. 8, No. 3, p. 267," the "No. 3" is superfluous if page 267 is nowhere else in volume 8 than in No. 3. If the pagination starts afresh with each number that item must be included.

Of course under some conditions the need of saving space may be so urgent as to overbalance the disadvantage of omitting these terms. For example, in the list of geologic literature on North America from 1785 to 1918 (U. S. Geological Survey Bulletin 746) it was necessary, in order to keep the volume within reasonable dimensions, to cut the citations to the bone, and even the periods after abbreviations were omitted. In this book, which with all the condensation still contains 1,167 pages, the Brewer citation given above appears as "Am J Sc (2) 42: 114–118 (1866)" The plan was clearly explained in the introduction, however. Such exceptional conditions should not furnish a guide for ordinary practice.

In some styles the title of the paper or book cited is set in small capitals or inclosed in quotations; in others italic is used for the title of the journal cited. There is no need for such typographic distinctions. Plain roman "lower case" is easier to read than any other style. A title set in all small capitals is especially hard to read and is also typographically ugly.

In order of items the U. S. Geological Survey style corresponds to practically all other styles in most respects. The author's name is inverted, as it appears on library cards and in catalogs. If it seems necessary to identify the author by telling who he is, the designation is given in parentheses after his name: "McDonough, D. C. (American consul, La Paz)," etc. The position of the date of publication is sometimes questioned. It is placed last for several reasons:

(*a*) It appears last on the title-page of a book.

(*b*) In most references to serial publications the volume number is the principal distinctive item of identification and the date is simply additional information, more or less incidental, though important where questions of priority are involved. The distinctive item should be given first.

(*c*) A volume may run over more than one year, and the date used in the citation should of course be that of the particular pages cited. To write, for example, "vol. 43, 1893, pp. 6–20," and "vol. 43, 1894, pp. 296–371," is obviously less desirable than to put the date after the pages to which it belongs.

(*d*) The annual report of an organization covering the operations of one calendar year is of course not published until the following year. To put the date of publication directly after the title, as in "Arkansas Geol. Survey Ann. Rept. for 1928, 1929, pp. 24–36," is confusing, to say the least. These dates might be taken to mean a fiscal year covering parts of both 1928 and 1929, though the proper form for that would be "1928–29." Placing the date of publication at the end, however, removes the confusion. (To make such references to annual reports clear, the "for" should always be used, whether it appears on the title-page or not. If, however, the reports are numbered, as in "Fiftieth Annual Report," that is sufficient identification, and it is unnecessary to give the period covered.)

(*e*) An illustration of the difficulty arising when the date is put anywhere except at the end is afforded by the following citation: "Soc. géol. France Mém., sér. 2, vol. 8, No. 3, p. 404, 1868." Série 2 of the Mémoires comprises ten volumes, published at intervals from 1844 to 1877; volume 8 contains three papers, published in 1865, 1866, and 1868; the date 1868 applies to No. 3 and page 404 in this citation and to nothing else.

(*f*) Some journals are published in two volumes a year, and the date is thus not an exact indication of the particular volume cited. Here again the distinctive item should be given first.

It is occasionally desirable to arrange a list of citations chronologically. To emphasize this arrangement the date may be transposed from the end to the beginning of the citation, but no other change is required. When that is done a period is used after the date.

The one apparent exception in Geological Survey style to the rule of placing the date last is not a real exception. Some journals have no distinctive numeral designation other than the year of publication. For example, the Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie has no distinctive volume number but is issued as Band 1 and Band 2 in each year. In citing this journal the year must be given as a substitute for the volume number—"Neues Jahrb., 1929, Band 2, pp. 67–104"—and is not repeated at the end. In such a citation the date is not really shifted from its normal position: it is used for another purpose, and then, repetition being unnecessary, it is omitted as the date of publication.

The standard abbreviations used by the Geological Survey for titles of serial publications are based in general on the principle of giving enough to indicate the words clearly. For example, "Jour." is used for Journal, not "J.," which might mean Jahrbuch or Jahresbericht.

The capitalization follows the usual library style. In English titles of books or papers only the first word, proper nouns, and proper adjectives are capitalized; in English titles of serial publications (usually abbreviated) principal words are capital-

ized. In foreign titles national practice is followed throughout.

The use of Latin terms in footnotes to avoid repetition of titles is confined to "op. cit." and "idem." "Op. cit." may be used if the previous reference is not far away, provided there can be no doubt as to what work is cited. If two works by the same author have been cited previously it is necessary to repeat the reference. "Idem" is used only for a second citation of the same work, immediately following the first, on the same page. "Idem" may represent all of the preceding citation except the page numbers, or it may be used to represent simply the journal just cited, the author and title being different. The forms "id.," "ibid.," "ibidem," and "loc. cit." are not used—not because they are not good Latin but for the sake of simplicity. Even "op. cit." should be used sparingly.

Most features of the Geological Survey scheme are regarded as having obvious advantages; a few represent simply a choice among different styles to insure uniformity. Owing to the vagaries of publishing organizations no scheme can provide for every difficulty that may arise. For troublesome citations that are not covered by the general rules common sense and analogy must serve as guides.

BERNARD H. LANE,
Editor

U. S. GEOLOGICAL SURVEY

REGARDING TWIST IN CONIFERS

I WAS much interested in Mr. Chester K. Wentworth's article in the February 13 issue of SCIENCE concerning the twist in trees, especially at timberline in the Rocky Mountains. It has been my privilege to spend five years in the Colorado Rockies. During the summers of 1927 and 1928 I was stationed at the summer camp of the University of Colorado, which is located near timberline on the eastern slope of the Continental Divide. While here I spent much time studying the flora of the region and noticed particularly the twisted structure of most of the trees at timberline.

The same question asked by Mr. Wentworth was asked by members of different parties we were escorting, so two of the students and myself studied the question in an effort to find out what might be the cause of the twisting. We studied the living trees and those with one side alive, together with the dead ones in the vicinity. Knowing how hard it would be to prove an hereditary tendency toward twisting, we looked for an environmental explanation. From this angle three factors entered into our study, namely: (1) Direction of winter storms; (2) direction of prevailing winds during growing season; (3) natural protection, especially during the younger stages of growth.

It was obvious to the observer that the trees most strongly twisted were entirely devoid of branches on the upper or northwestern side. Upon studying the weather maps of the region we learned that the prevailing heavy storms of winter came from that quarter. These storms, laden with ice and sleet, cut off the small, tender twigs and consequently no branches were formed on the windward side. This left the tree much like a flag with the surviving branches pointing to the south and east. Further study of the weather maps together with our own knowledge of the summer winds told us that the prevailing winds of summer came from the south and west. We could now see that this lopsided tree with its branches on the east would be strongly whipped to the right during the time when its trunk cells would be most active and pliable. It is highly possible that this constant pressure to the right would strain the old fibers and also cause the new tissues to form in a slightly twisted condition. When the storms of winter came from the north and west the tree would tend to become untwisted but being dormant it would yield less in winter than in summer, consequently it would remain twisted. The only effect of the winter winds would be to destroy the tender twigs on the exposed portion of the "flag." The tendency would be to remove any twigs that may have been pushed farther to the right by the twisting during the summer. Thus the twigs would be built up on the left or south side of the "flag" in summer and be beaten off the right or north side in winter. During the lifetime of the tree it might mean the complete rotation of the upper part of the trunk. It is not uncommon to see branches twisted back over the top of the tree like huge arms pointing away from the wind. These may have been forced into this position by the process described above.

Twisting is not common in trees standing in thick timber, but occasional twisted trees are found at the edge of such stands. These trees may have been subjected to tornado twisting when young or may have been subjected to unequal strain when covered with drifted snow. This latter theory may account for left-handed twisting which is so infrequently observed. A few left-twisted trees were observed at timberline and with one exception these were protected in such a way by rocks as to receive the strong winds of summer at an angle which would cause the tree to be twisted to the left. This one exception stood out alone, but there were stumps of other trees near by which must have influenced its early growth. Both this tree and the dead stumps were protected from the northwest storms.

Twisting was not observed on the western slopes mainly because we were not stationed near these regions. It is likely that the same conditions would prevail there since the storms retained their same relative positions as on the eastern slopes.

Twisting of trees other than those at timberline has been observed and noted but not studied to any great extent. Apple trees are usually twisted in the prairie regions, but no definite set to the twist was noticed. It often occurred that both left and right twisting could be found in the same tree. In cutting up an old orchard that had died we found many trees of this type.

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THE GROWTH OF STALACTITES

An occurrence, similar to that discussed by Professor Ellis in Science for January 16, 1931, "Concerning the Rate of Formation of Stalactites," came to my notice during an inspection of Fort Delaware in the summer of 1929.

Fort Delaware is situated on Pea Patch Island, in the middle of the Delaware River, 12 miles below Wilmington and is of the pre-Civil War type with walls of gray granite and interior finish of high grade brickwork. Though started in 1848, it was not completed until after the Civil War.[1] Thus the setting is similar to that at Fort Pickens.

Abundant growths of stalactites were found in process of development from the brick arches on many of the lower casements, the material for their growth being supplied mainly from the lime-natural cement-sand mortar but perhaps to a slight extent from the bricks, which showed some spalling due to water action. These stalactites varied as to type, many being of the slender, fragile variety described by Professor Ellis, with the larger ones reaching over a foot in length, while others were much stouter, with a length of four to five inches and a diameter of over one half inch, and were therefore strong enough to be readily collected. They consisted of a pure white carbonate of lime. Lime deposits also covered the floors of these casements to a considerable extent and in a few cases the development of stalagmites was beginning to be noticeable. Deposition was still in active progress.

As Fort Delaware had already become practically obsolete by the time it was completed, deposition may have been going on undisturbed for as long a period as 60 years. On the other hand, as there was some activity at the fort during the Spanish-American War, 30 years may be set as the lower limit available for the growth of the longer stalactites.

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[1] Charles H. Roe, "The Building of Fort Delaware," *The Military Engineer*, Vol. 21, pp. 350–354, July–August, 1929.

A CASE OF A BOY POSSESSING AN AUTOMATIC DIRECTIONAL ORIENTATION

In a note in the *Psychological Bulletin*[1] twenty-two years ago H. C. Warren described the case of a boy who had an extraordinarily good sense of direction. A few months ago I wrote to this individual and asked him several questions about his sense of orientation. The answers received were all in the negative —that is, the individual disclaimed that he possessed any different sense of orientation than the ordinary person has who uses familiar objects or the sun as a guide. Whatever ability at orientation this individual had as a boy he has obviously lost as a man.

Recently a married couple who attended one of my classes reported that their son possessed an unusual sense of orientation to the points of the compass. He never seemed to get lost, they said, and when in a strange city could be relied upon to tell them in which direction they were going. While driving in an automobile through unfamiliar country he was able to tell the direction at any time.

With the cooperation of the parents I tested the boy in our psychological laboratory. I took him into a dark room, blindfolded him and confused him by revolving him (without, however, making him dizzy) in a noiseless rotating chair. After a few correct judgments he began to make large errors, and soon lost all absolute orientation. He oriented himself immediately as soon as he was permitted to see.

I convinced myself that he possessed no genuine "magnetic" sense of direction. This finding was corroborated by a story of his parents to the effect that if he went to sleep while riding in an automobile at night he was temporarily lost as to directions when he awoke. Regardless, however, of his lack of a sense of absolute orientation, it is exceedingly interesting that once he gains a true orientation during his waking hours he seems to remain oriented at all times. I might add that he is twelve years of age, above the average in intelligence and curious about everything that goes on around him.

His mother furnished an interesting bit of information on the origin of the development of this sense of orientation. As she is left-handed and frequently confuses "to the right" with "to the left," she used to give orders of the following sort to the youngster:

[1] H. C. Warren, "Magnetic Sense of Direction," *Psychol. Bull.*, 5: 376–377, 1908.

"Get me the brush on the north side of the dresser," "Go and sit in the chair on the east side of the porch." She did not do this to train his sense of direction but merely because it was more convenient and less confusing for her. Out of this training the boy has apparently developed the unusual ability to move about a complicated path for relatively long periods of time and retain his orientation without paying attention to the process.

From a theoretical angle the fact that this boy has learned to orient himself for long periods of time over a devious path while occupying his mind with many other things furnishes a clue to help us to understand how certain birds and animals can wander for long distances and find their way home over unfamiliar territory. If this boy can orient himself to the compass directions without voluntary attention to the task for long periods of time, then it is not difficult to conceive why certain animals, to whom such an ability would have an important survival value in hunting or being hunted, can likewise maintain this sense of continuous automatic orientation, if not to points of the compass, at least to their homes.

It is obvious that other factors need to be discovered to explain the case of an animal being blindfolded, confused and carried for a considerable distance and then finding his way home, but then many animals can not carry out this stunt. Perhaps in the few cases reported where animals have been successful in this performance, certain cues that might have enabled them to retain this continuous automatic orientation were not eliminated.

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MENDELIAN DIFFERENCES

MAY I be permitted to correct an error of attribution before it becomes more widely spread in the biological literature. Dr. E. S. Russell, in his recent very interesting book, "The Interpretation of Development and Heredity" (p. 64), quotes Johannsen[1] as responsible for the conception that Mendelian inheritance deals with *differences* rather than similarities. It is necessary to point out that this conception originated in a paper of mine[2] in 1915, where the matter is fully developed. It was also referred to again in my book "The Mutation Factor in Evolution" (1915, p. 313).

It is worth pointing out that in the same paper (p. 141) Johannsen uses the conception of a particular constitution as characteristic of every cell in each genotype. This conception is clearly stated in "The Mutation Factor" (p. 297) and, as is well known, was based originally upon the Oenothera mutations which have an extra chromosome in every nucleus. It was further considered in various aspects in "Mutations and Evolution."[3]

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE REMOVAL OF TRACES OF OXYGEN FROM NITROGEN

THREE general methods have been used to remove traces of oxygen from nitrogen: (1) To pass nitrogen through a solution which will remove the oxygen; some of the solutions used have been alkaline pyrogallol, ammonium cuprous chloride and alkaline hydrosulfite, with or without a catalyst as anthraquinone sulfonate suggested by Fieser.[1] (2) To remove oxygen with a solution such as ammonium cuprous chloride, which was placed in a large cylinder containing the gas under pressure; nitrogen, free from oxygen, but containing traces of ammonia, is delivered from the cylinder.[2] (3) To pass the nitrogen over a hot metal which will remove the oxygen and form the oxide of the metal; for this, copper has been shown to be much the most efficient, and has been used by the majority of investigators.

Variations in the potentials of solutions of cysteine which were observed in my laboratory when this type of purification was used indicated that under some conditions all traces of oxygen were not removed by the copper and suggested a reinvestigation of the problem concerned with the removal of oxygen from nitrogen.

Previous work had shown that a flow of between 200 and 500 cc of nitrogen a minute was desirable. For the removal of the traces of oxygen from this volume of nitrogen many different forms of tubes and furnaces were prepared and investigated. These need not be described in detail; the results eventually have led to a tube which has been thoroughly tested and has been proved to be satisfactory. It possesses several advantages when compared with the old type of copper furnace.

[1] L. F. Fieser, *J. Am. Chem. Soc.*, 46, 2638 (1924).
[2] H. Wartenberg, *Zeitschr. f. Elektrochemie*, p. 295 (1930).

[1] "Some Remarks about Units in Heredity," *Hereditas*, 4: 133–141, 1923.
[2] "Heredity and Mutation as Cell Phenomena," *Amer. J. Bot.*, 2: 519–528.
[3] New Phytologist Reprint No. 12, pp. 118, 1921, now published by the Cambridge Press.

Popoff[3] has suggested the use of the heated filament of a tungsten incandescent light for the purification of hydrogen. It was hoped that copper wire could be substituted for the tungsten and that it could be electrically heated to such a temperature that the traces of oxygen in nitrogen would combine with the copper oxide thus formed and would not be decomposed. With a 110 volt heating current, either an extremely long wire of large cross-section may be used or a shorter wire of small cross-section. No. 28 copper wire was chosen. A sufficient length to give 10 ohms resistance was wound on a triangular glass frame of pyrex rod. The frame was placed inside of a pyrex tube and suitable arrangements were made for the passage of the electric current and for the flow of nitrogen. It was then found that the wire expanded, short circuited and soon burned out.

This suggested a separation of the furnace into two parts, an inside heating element, and copper in the form of gauze to take up the oxygen. A cylinder of 40 mesh copper wire gauze 60 cm in length was wrapped around the outside of a 26 mm pyrex glass tube. Between the 26 mm glass tube and the copper gauze was placed a strip of mica which covered about a fourth of the surface of the inside of the copper gauze. Two thicknesses of copper gauze were wound around the tube and the strip of mica. The copper gauze was securely fastened with copper wire. The glass tube was then withdrawn, leaving a tube of copper gauze. This was placed inside of a pyrex glass tube 34 mm outside diameter and a coil of nichrome wire 0.5 cm in diameter, which contained 7.5 meters of No. 18 nichrome wire, was placed inside of the tube of copper gauze. A rod of silica 6.5 mm in diameter was placed inside the coil of nichrome wire to prevent distortion of the coil. The nichrome heating element rested on the mica. Copper wire for the connections to the heating element was sealed through the glass tube (Fig. 1).

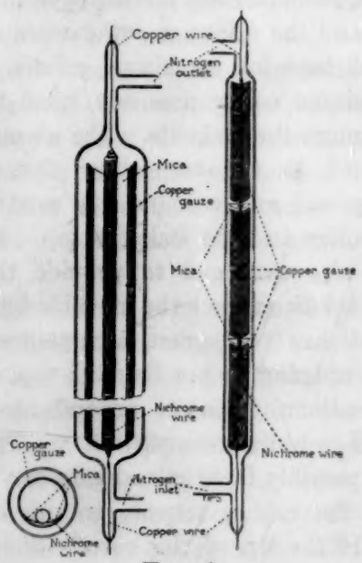

FIG. 1

Such a furnace has the following six advantages: (1) It is open for the free passage of the gas, the heating element and the copper occupy only a small part of the cross-section of the tube, and the velocity of the flow of nitrogen through the tube is, therefore, not increased. (2) The temperature to which the pyrex glass is heated (not above 300°) is too low to soften the glass. The pyrex tube therefore is not subjected to severe thermal changes and will last indefinitely. (3) The temperature to which the nitrogen is heated may be made maximal. The nichrome coil may be heated to any temperature desired up to decomposition of the nichrome. From 400 to 600° is sufficient to insure a high degree of reactivity of the traces of oxygen so that the oxygen rapidly combines either with the nichrome or the copper gauze. (4) The temperature of the copper gauze is high enough to insure the rapid reaction with all traces of oxygen, but it is not sufficiently high to drive off the copper oxide which has been formed. The position of the gauze in contact with the pyrex glass tube insures the maximal conduction of heat from the copper through the glass. (5) The tube is made of light construction and is not bulky. This fact permits a convenient arrangement of the tube in connection with electrode cells. (6) All parts of the tube are visible and the condition of the tube can be checked up without difficulty.

The first four points which have been considered are in strong contrast to the conditions present in a pyrex glass tube filled with copper wire and heated by an outside furnace. In such a furnace the velocity of the gas through the tube is high because of the bulk of copper. The pyrex glass tubing is subjected to great thermal changes. It may be ballooned out by pressure of the gas or collapsed due to a vacuum which may be produced in the system. The oxygen in the nitrogen is heated to a sufficiently high degree to react with the copper, but copper oxide is readily decomposed into copper and oxygen at a temperature which is sometimes used in this type of furnace.

With the new type of furnace the volume flow can be raised to 500 cc a minute and the copper oxide does not form for a distance of more than 4 cm from the entrance end. Even after 24 hours, not more than 15 cm of the gauze will be tarnished with the oxide. The reduction of the copper oxide with hydrogen requires but a few minutes.

Continued use of the furnace brings about changes in the properties of the copper. It looses ductility and becomes highly reactive to oxygen. If air at

[3] S. Popoff and A. H. Kunz, *J. Am. Chem. Soc.*, 51, 382 (1929).

laboratory temperature is passed through the tube, the copper becomes tarnished. When first prepared and at occasional intervals it is best to oxidize the copper with a rapid current of air through the tube while it is heated. This appears to burn off oil and other substances which cover the surface of the copper. The copper oxide formed is then reduced with hydrogen. This results in an enormous increase in the surface of the copper because of the cracked and seamed surface of the copper oxide. Reduction with hydrogen does not greatly change the physical appearance of this surface.

The removal of traces of oxygen from nitrogen in such a tube is complete. In addition the tube provides the solution of another important problem. It is possible to pass water vapor through the tube without the formation of even traces of hydrogen. Even if the water vapor is decomposed on the surface of the nichrome wire, the presence of the copper oxide completely removes all traces of the hydrogen so formed. All traces of hydrogen originally present in the nitrogen are removed as completely as is the oxygen.

In connection with studies of the oxidation reduction potentials of cysteine, an apparatus was prepared which consisted of eight electrode cells and two movable burettes, essentially similar to those described by Clark and coworkers.[4] Experience with such an apparatus over a course of several years has shown that deKhotinsky cement seals are frequently the source of contamination of the nitrogen with oxygen. Copper tubing, for the distribution of the nitrogen to the cells and burettes, also has been shown to be unsatisfactory. It therefore became necessary to modify the apparatus in order to make available a continuous source of nitrogen free from oxygen.

As it is desirable to see the contents of the electrode cells, the eight cells and the new type of copper gauze furnace which has been described were mounted on a framework which was counterbalanced and could be raised and lowered into the oil thermostat. Pyrex glass tubing connected the copper furnace to a distributor with eight pyrex stopcocks which terminated in pyrex tubing 8 mm in diameter. The eight delivery tubes from the distributing tubes fitted into eight mercury seal cups which were attached to the eight tubes that delivered the nitrogen to the electrode cells. A "Y" tube was placed in the distributing line and the nitrogen was connected to the two movable burettes by means of flexible copper tubing, 6 mm in diameter. Since copper tubing may be the source of contamination with oxygen, the nitrogen was passed through another small copper gauze purification furnace which was placed at the entrance of each burette. A diagram of this furnace is shown in Fig. 1. Continuous pyrex tubing connected this furnace with the movable burette.

In addition to these precautions for the removal of oxygen, the construction of the electrode cell was also modified. The tops of ten ounce nursing bottles were ground off on a steel plate with emery powder so that the top of the bottle was in one plane, parallel with the bottom, and presented a broad ground glass surface. Circular Bakelite caps, one cm in thickness, with flat-bottomed circular grooves which fitted the tops of the ten ounce bottles were held in place with a suitable frame which extended around two sides and across the bottom of the cell (Fig. 2). The bottle was

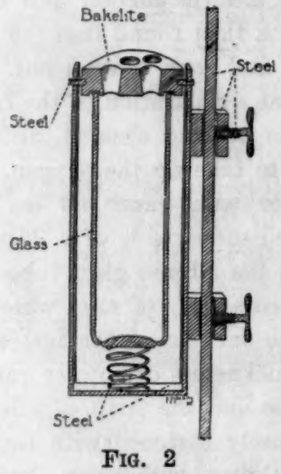

FIG. 2

securely held in the frame by a spring which pressed the cell against the Bakelite top. When vaseline was placed in the groove of the Bakelite top and the nitrogen outlet was closed, the vaseline seal between the ground glass top of the cell and the Bakelite top would withstand a pressure of 2 kilos. Through the Bakelite top, the electrode, the nitrogen inlet, the agar salt bridge and the nitrogen outlet were all arranged by means of tapering aluminum collars. The taper of the aluminum collar precisely fitted the taper in the hole through the Bakelite. The aluminum collars were fastened to the respective glass tubes with deKhotinsky seal and vaseline was used between the aluminum collar and the Bakelite top. The nitrogen outlet was also arranged to provide the inlet for addition of solutions from the movable burettes. This arrangement has two great advantages. First, it removes an opening in the Bakelite top, and, second, nitrogen continually passes around the tip of the burette and rapidly removes all traces of oxygen which may possibly have gained entrance to the outlet tube when the rubber stopper to this opening was removed. If the tip of the burette is placed in the nitrogen outlet and allowed to remain for one half minute or so before addition of the solution to the cell, the nitrogen will rapidly sweep out all traces of

[4] Hygienic Laboratory Bulletin No. 151, p. 35 (1928).

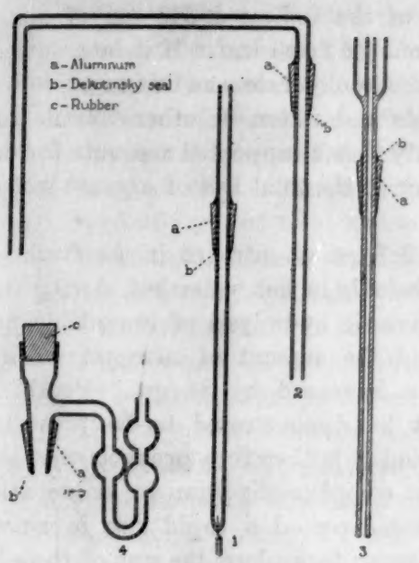

FIG. 3

oxygen. DeKhotinsky seals made as described are much more secure than if made without the collar of metal. Any other suitable material could be used in place of aluminum; this metal is easy to work on the lathe and has been found to be satisfactory in every way (Fig. 3).

Evidence that the copper furnace completely removes all traces of oxygen and that the construction of the electrode cells and movable burettes satisfactorily meets all requirements will not be included in this paper, but will be given in the papers dealing with the reaction of cobalt salts with cysteine, and the oxidation reduction potential of cysteine and glutathione.

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SPECIAL ARTICLES

THE CHEMICAL CHANGES THAT OCCUR DURING THE CURING OF TOBACCO LEAVES[1]

IT has long been assumed that the metabolism of excised leaves follows a relatively normal course for quite appreciable periods of time, and that differences that arise between the chemical composition of such leaves and the intact leaf are due to the cutting off of the food supply from the stem and to the interference with the outlet for the products of metabolism; storage of these products therefore occurs. Subsequently, however, the changes become more patently katabolic; extensive dehydration of the tissue takes place if water is not supplied and this brings in its train a whole series of complex changes, many of which can be recognized as the results of the activity of well-known types of enzymes.

The curing of tobacco under commercial conditions affords an excellent opportunity for the study of these katabolic changes, since the soluble substances in the large thin leaf of this plant can be readily extracted by means of hot water and adequate quantities of leaves of uniform size and development are easily secured.

In order that definite comparisons might be established between leaf tissue which had reached different stages of the curing process five 50 kg lots of leaves (8th to 11th leaf) were picked from the plants the same day (August 1, 1929). One of these lots was immediately extracted with boiling water, the other four lots were strung on cords in the customary manner and suspended in a curing shed. The second lot was removed and extracted at the expiration of 12 days when all the leaves had become yellow, the third lot at the expiration of 18 days when the leaves had first become a uniform brown color, the fourth at the end of 51 days when the leaves were pronounced "fully cured," and the last lot was subsequently fermented along with the main crop of tobacco from the same field. Each lot was extracted with hot water in the same way. The leaves were dropped slowly into a large volume of boiling water to which sufficient sulphuric acid was added from time to time to maintain the reaction at or near pH 4.0; loss of nicotine was thereby avoided. After boiling until the mid-ribs were soft the leaves were pressed at the hydraulic press. The residues were then ground in a meat grinder and re-extracted with boiling water. This process was repeated once more. The three successive extracts were collected quantitatively, were filtered and concentrated *in vacuo* to 8 l. Analyses of extracts and extracted residues were then carried out, the methods for total, ammonia, amide and nitrate nitrogen employed being those recently developed in this laboratory,[2] amino nitrogen was determined by Van Slyke's method and the total solids, ash, crude fiber, soluble carbohydrate and ether soluble solids were determined by standard methods.

Inasmuch as each lot of leaves was initially of the same weight and the leaves were individually of the same size[3] and age, comparison between the different lots could be established by calculation of the absolute

[1] The expenses of this investigation were shared by the Connecticut Agricultural Experiment Station and the Carnegie Institution of Washington, D. C.

[2] H. B. Vickery and G. W. Pucher, *J. Biol. Chem.*, 83, 1 (1929); *Ind. Eng. Chem., Anal. Ed.*, 1, 121 (1929); G. W. Pucher, C. S. Leavenworth and H. B. Vickery, *Ind. Eng. Chem., Anal. Ed.*, 2, 191 (1930); H. B. Vickery and G. W. Pucher, *J. Biol. Chem.*, 90, 179 (1931).

[3] The uniformity of the material is evident from the fact that the 12-day lot contained 2,014 leaves and the 18-day lot contained 2,011.

weight of each component at each stage of curing. Loss or gain of any component could then be readily determined. This method of calculation gives results that are much more easily appreciated than those founded on a percentage basis since the total solids and total nitrogen, which are customarily employed as the fundamental data, both underwent substantial changes.

After completion of the curing process the 50 kg of fresh leaves weighed only 6.68 kg. By far the greater part of the loss of weight was due to the evaporation of water. The fresh leaves contained 43.53 kg of water and 6.47 kg of dry solids, the fully cured leaves contained 1.49 kg of water and 5.19 kg of dry solids, consequently 42 kg or 96.4 per cent. of the water originally present had evaporated. The magnitude of the loss of solids is striking. Approximately 1.3 kg or 19.8 per cent. of the whole disappeared, and this loss was found to fall exclusively, as might be expected, on the organic matter of the leaf. A detailed discussion of the types of substances that contributed to this lost material can not be attempted in this place[4] but the data strongly indicate that more than half of the material that disappeared had its origin in protein.

There were 426 gm of other soluble material in the fresh leaves; after 12 days 347 gm were present and after 51 days only 260 gm remained. This represents a loss of about 39 per cent. of the initial quantity during the curing process. Much of the extensive early change in the quantity of ether soluble material present is probably associated with the destruction of the chlorophyll which was practically complete at the end of 12 days. The fresh leaves contained 92.5 gm of chlorophyll. On the assumption that decomposition to chlorophyllides and phytol occurred, two thirds of this amount should have been converted to substances of rather low solubility in ether at the time the chlorophyll was no longer recognizable in the leaf. During the entire curing process, however, other and quantitatively much more extensive changes also occurred. In how far these were due to conversions of ether soluble substances to ether insoluble substances rather than to direct loss from the leaf (*e.g.*, by evaporation) was not ascertained.

The amount of crude fiber in the leaves underwent no change, but the amount of soluble carbohydrate, estimated from copper reduction as glucose, diminished from 348 to 65 gm, a loss of more than 81 per cent. That a considerable part of this carbohydrate was either glucose, fructose or mannose was demonstrated by the isolation as phenyl-glucosazone of 48 per cent. of the indicated 348 gm of sugar in the extract from the fresh leaf. If it be assumed that all the loss of carbohydrate was due to oxidation to carbon dioxide and water, or other volatile substances, the quantity that disappeared accounts for only about one quarter of the total loss of organic matter during curing.

Of the 288 gm of nitrogen in the fresh leaves 105 gm were soluble in hot water but, during the first 12 days, enzymatic hydrolysis of coagulable protein occurred and the amount of nitrogen soluble in hot water was increased by 84 gm. Peptide nitrogen could not be demonstrated to be present in these extracts and it is therefore probable that the protein underwent complete digestion to amino acids. During the same period a rapid rise in ammonia and amide nitrogen took place, the sum of these increasing from 4.3 to 36.8 gm. Extensive deamination of the amino acids followed by amide synthesis must, therefore, have occurred. These observations are in complete agreement with those of Chibnall[5] on starved runner bean leaves.

The magnitude of the quantities of nitrogen involved in these conversions can best be appreciated from a consideration of the data for the whole curing period. The total nitrogen of the leaves decreased from 288 gm to 246 gm but evaporation of nicotine accounted for a decrease of only about 4 gm. The remaining 38 gm therefore represent nitrogen that escaped from the leaves in some other form of combination, in all probability as ammonia. Inasmuch as the nitrogen in the water insoluble residues of the leaves diminished from 182.8 to 72.5 gm, an amount of protein that contained approximately 110 gm of nitrogen was converted into a form soluble in hot water. Calculation from the sum of the ammonia and amide nitrogen present at the beginning and end of the curing process, with due allowance for the 38 gm of nitrogen that escaped from the tissues, showed that no less than 69 gm of nitrogen passed through the ammonia or amide nitrogen stage. While it is improbable that all this was originally in the form of protein and was derived from the 110 gm of nitrogen in the protein that was digested, it is evident that no less than 23.9 per cent. of the total nitrogen of the leaf passed through one or both of these stages. Deamination of amino acids and synthesis of amides are therefore of great importance during the curing of the tobacco leaf.

An approximate idea of the proportion of the original protein nitrogen that shared in these reactions was secured from a study of the amino nitrogen in the extracts and of the amino nitrogen yielded by the leaf residues after these had been subjected to

[4] A full discussion together with the complete data of this investigation will be presented in *Bulletin* 324, Conn. Agr. Exp. Sta. (1931), in press.

[5] A. C. Chibnall, *Biochem. J.*, 18, 387, 395 (1924).

complete hydrolysis. The difference between the amounts of amino nitrogen produced by acid hydrolysis of the residues at two successive stages may be regarded as a measure of the amino nitrogen which gradually passed into solution as the katabolic reactions in the tissues proceeded. The residues from the fresh leaves yielded 104 gm of total amino nitrogen, those from the leaves that had been cured for 12 days yielded only 53 gm, consequently in this period 51 gm of potential amino nitrogen must have passed into a soluble form. But, instead of a corresponding increase of 51 gm of amino nitrogen in the extract from the 12-day cured leaves, this increase amounted to only 26 gm; 25 gm of amino nitrogen disappeared as such. It was found, however, that the accumulation of ammonia and amide nitrogen that occurred amounted together to approximately 28 gm, which corresponds satisfactorily to the observed deficit of amino nitrogen. It is clear, then, that at least half the potential amino nitrogen of the protein that underwent enzymatic hydrolysis in the first 12 days was further converted to ammonia and amide nitrogen.

The approximate constancy of the quantities of ammonia, amide and amino nitrogen in the extracts from the more fully cured specimens of leaves suggests some sort of an equilibrium condition in the relationships between these forms of nitrogen. In the period from 12 to 51 days the sum of the three forms diminished by only 5 gm. The unassigned or "rest" nitrogen likewise diminished by about 5 gm in spite of the fact that, during this interval, some 23 gm of nitrogen, originally present in the form of coagulable protein, were converted to a soluble form. Extensive changes took place in the forms in which the nitrogen is combined in the leaves and the data suggest that, although many side reactions doubtless occurred, the *essential* sequence of reactions was, protein nitrogen → amino acid nitrogen → ammonia nitrogen → amide nitrogen. Whether the nitrogen that escaped from the tissues, presumably in the form of ammonia, was derived from subsequent hydrolysis of the amides or directly from the deamination of amino acids was not ascertained. Probably both sources were available since the presence in the leaves of enzymes that hydrolyze amides was suggested by the extensive decrease in amide nitrogen that ensued during fermentation of the fifth lot of leaves.

Perhaps the most significant result of these studies is the demonstration of the rapidity of the katabolic reactions during the early stages of curing. Three quarters of the loss of water and of soluble carbohydrate and more than half of the loss of organic solids and of ether soluble constituents occurred during the first 12 days; more than three quarters of the quantity of protein digested underwent this process in the same period. It is obvious that far-reaching chemical changes set in very shortly after leaves are detached from the plant.

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POLLEN-STATISTICS: A NEW RESEARCH METHOD IN PALEO-ECOLOGY

THE number and importance of the papers on ecology in American botanical literature clearly testify to the popularity of ecology among American botanists. Yet the domain of Paleo-ecology has been almost untouched, although researches along such lines would, in many cases, lead to a better understanding of actual ecological problems. In Europe no other branch of Paleo-ecology has been more popular during the last years than pollen-statistics, or the method of tracing the history of the forests from the occurrence of the fossil tree pollen grains in peats and sediments, which was elaborated some twenty years ago by the Swedes G. Lagerheim and L. von Post. There are signs that an activity in this field similar to that in Europe is not far off in this country, and it has been considered appropriate, therefore, to give here a brief description of the working methods, together with some practical hints which might prove useful to beginners.

THE FIELD WORK

The field work is chiefly confined to the summer. During the winter, however, when the lakes are frozen over, samples of bottom sediments could be obtained by means of borings through the ice. Several types of boring rods are in use. The more obsolete ones are being supplanted more and more by the Hiller peat auger, manufactured by the Beus and Mattson Company of Mora, Sweden. This company offers the auger in two different models; a smaller one with extension rods of 100 cm each, which is kept in a leather case and carried by a strap over the shoulder, and a bigger one with extension rods of 150 cm each. The approximate cost of the two models is about twenty-five and forty-five dollars, respectively. If the field work is carried out with the help of an assistant, preference should be given to the heavier auger, which is more reliable than the smaller one. The field apparatus also includes a spade, a big knife, forceps, glass tubes in which to keep the samples (about 7.5 cm long and 1.3 cm inside diameter and corked at both ends), diopter compass, and a geodetical set for taking levels and distances.

At the boring place a big sod of the surface material is first removed with the spade. From the walls of the sod the first samples are taken, say, from 2, 5, 10, 15 and 20 cm below the surface. Then the auger

is put in the hole left by the sod, and forced down in the peat. Meanwhile the handle of the auger should be kept turning slightly to the right (clockwise) to prevent the opening of the container. Then the container is opened, and a good and compact core is obtained if the handle is turned, swiftly, about eight times (four revolutions), counter-clockwise. It is then closed by a couple of turns to the right, and the auger is pulled up out of the peat during a continued slight revolution to the right. Samples are taken with the forceps at regular intervals, *e.g.*, at every fifth cm, out of the core of the container, since the outer layer of the core, which might be contaminated, has been removed with the knife. The forceps should be nickeled and have smooth ends.

It is useful to have the spade standing nearby the boring place and to put the lower end of the auger with the container through its handle when the samples are taken. Fig. 1 shows, schematically, a

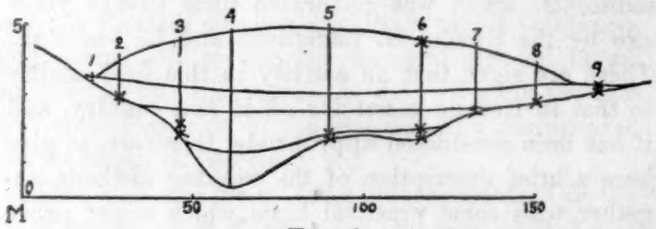

FIG. 1

section of a bog, the stratification of which has been made out from serial borings. A series of peat samples would most suitably be gathered from point 4, and additional samples for the study of the growth of the bog and the composition of the sub-recent pollen flora, etc., from the places marked with a cross.

THE LABORATORY WORK

When preparations for microscopical investigation are to be made, a small amount of peat is taken from each end of the substance enclosed in a glass tube, laid on a slide and mixed with 10 per cent. caustic potash. The slide is held with a clothes pin and the mixture is carefully boiled over a small alcohol flame until the greater part of the water has evaporated. Some drops of glycerine are then added and mixed with the peat, and a part of the mixture is removed to another slide and covered with a cover-glass. The pollen-grains are then counted by the use of the micrometer stage of the microscope. A magnification of about 200 times is required, and then a high power lens for the study of the finer details of the exine. Some sediments need no boiling and preparations are simply made by mixing a part of the substance with distilled water. Calcareous material is treated with dilute hydrochloric acid and minerogene earths, even rather coarse sand, could be subjected to pollen-analysis if centrifugated and treated with hydrofluoric acid.

Trustworthy percentages are obtained if about 150 pollen-grains are counted. The frequency of the pollen-grains of hazel, willows, and other species which are more or less confined to the under-growth of the forests, is calculated separately and expressed as a percentage of the sum of the pollen-grains of the forest trees proper. Thus, a willow pollen frequency of 138 per cent. indicates that the number of willow pollen-grains in that preparation was bigger than the sum of the pollen grains of the forest trees. The frequency of *Sphagnum* spores, tetrads of *Ericaceae*, etc., is expressed in the same way. It is useful, too, to have a record of the PF, or pollen frequency per square cm, from each preparation.

By means of the percentage figures, a *pollen-diagram* is constructed. The relative frequency numbers, which are produced for the pollen-species found in a sample, constitute the *pollen-spectrum* of the sample. On the basis of a series of pollen-spectra from a boring in a bog, a pollen-diagram may be constructed, with the depth of the peat as ordinate and the pollen percentages plotted down on abscissae corresponding to those levels from where the samples were taken. In a pollen-diagram the curves for the single species or for a group of species give both a visual representation of the composition of the pollen flora and the oscillations as regards frequency which have taken place reciprocally between the pollen-curves during the formation of a bog.

Great difficulties are often encountered in identifying the pollen grains. Illustrations should not be relied on, but everyone working with pollen-statistics should have access to reference preparations of pollen-grains from recent trees. Such preparations could be made directly from fresh material or from boiling stamens of herbarium specimens with 10 per cent. caustic potash and mounting the pollen grains in glycerine jelly. After some practice it would be possible also to identify pollen grains of different species within the same genus; for instance, to distinguish the pollen of *Picea canadensis* from the slightly smaller one of *Picea mariana*, that of *Pinus murrayana* from that of *Pinus banksiana*, etc. In some cases, complete variation statistical analyses must be made. As to *Pinus* and *Picea*, it might be useful to calculate and plot down in a reference table the limits within which the dimensions of the pollen grains vary. As in the preparations some pollen grains are only shown from above, obliquely, or contorted, or, even in mere fragments, as isolated wings, not only the breadth of the pollen grains should be measured, but also the height and depth of the pollen grain proper, and the breadth, height and depth of the wings.

Notes on the finer structure are desirable; also notes on the color, which might vary according to the chemicals used.

After the study of recent pollen grains, it would be advisable to search samples from the surface of the peat for pollen grains. The pollen grains found among the branches of living *Sphagnum* and in the moss cover of stumps and fallen trees give a picture of the composition of the contemporaneous pollen grains. That would give a key to the conclusions which can be drawn from fossil pollen in general, but, in this respect, too much care can not be exercised. We know, for instance, that pollen grains can be carried by wind for very long distances, so that coniferous pollen might be encountered in the peats of Greenland; and, further, that the pollen grains of some trees might be under-represented in the pollen-spectra, owing to their being distributed at a time when the lakes and the peat surfaces are still frozen, or from other causes are not as fit for catching and preserving the pollen grains as at a later season. Because the delicate *Populus* pollen grains may not be preserved in peat, it is understandable, too, that a virgin Cordilleran coniferous forest would produce somewhat the same pollen-spectra in the mountain bogs as do some of the poplar forests, with scattered conifers, in the muskegs of the Great Western Plains. I do not mention this to discourage any one wishing to take up pollen-statistics. Its renown as a good and helpful paleontological research method can not be jeopardized, as shown by its success in Europe. I only mention it because, in my opinion, a thorough study of the recent and sub-recent pollenflora of American bogs would be more valuable as a start for pollen-statistical investigations in America than the presumably rather hazardous task of identifying a multitude of pollen types from old deposits with material often much decayed and altered.

Further information on pollen-statistics can be obtained from the papers listed in "Literature on Pollen-statistics published before 1927" (Geol. Fören. Förh., 49, 196–211, Stockholm, 1927) and "Literature on Pollen-statistics published during the years 1927–1929" (ibid., 52, 191–213, 1930).

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STRUCTURAL AND FUNCTIONAL VARIATIONS OF FIBROBLASTS IN PURE CULTURES

A MEDIUM has already been described[1] for the long-continued cultivation of mesenchyme cells under conditions which allow of very limited cell proliferation. Instead of the cells being fed upon the growth-promoting substances contained in embryonic tissue juice, they are treated with adult blood plasma. Cultures which are so nourished grow very slowly and can be kept in good condition over a much longer period of time than cultures which are allowed to proliferate at their maximum rate.

The experiments here reported have given additional information concerning the properties of cells as manifested under conditions of slow growth. The material consisted of various pure strains of mesenchyme cells which were isolated simultaneously from an embryo chick. These strains were derived from heart muscle, skeletal muscle, the perichondrium of cartilage and the periost of bone, respectively. Although these cell types exhibit striking differences in their nutritional properties,[2] it has not yet been possible to distinguish them morphologically. Until used for the experiments, which were made in flasks, the strains were carried by the hanging drop method on media favorable for the maximum proliferation of the various cell types. Each series of experiments was made at the same time from strains of the same age. Although regularly washed and treated with blood plasma, a number of cultures which have been allowed to remain in the same flasks for as long as one hundred days without being disturbed have continued to show appreciable growth over the entire period. In the case of those cell strains which become early adjusted to the plasma medium, growth becomes progressively more and more active from passage to passage. Sufficient heparin is added to the plasma to prevent its coagulation during each period of treatment. In the concentration used, appropriate experiments have shown, however, that the heparin has no appreciable effect upon the rate of growth of fibroblasts. When the cultures are subdivided and transferred, the new clots are allowed to coagulate spontaneously without the customary addition of tissue juices, and the same manner of treatment is resumed. Hence, we can definitely state that these cells are able to live and multiply at the expense of the food substances contained in the plasma alone.

It is undoubtedly true that the process of adaptation to the plasma treatment begins from the moment that the fibroblasts are transferred from an environment of ample food to one which is deficient in readily available food substances But while certain cell colonies are able to adjust themselves to the new environmental conditions without very pronounced structural changes in the cells themselves, it does not follow that this is always the case, even among sister

[1] A. Fischer and R. C. Parker, *Arch. f. exper. Zellforschung*, 8, 325, 1929.

[2] R. C. Parker, *Arch. f. exper. Zellforschung*, 8, 340, 1929.

cultures originating from the same strain. To illustrate: after the first series of experiments had been carried in the flasks under this treatment for about twelve days, it was noticed that the cells of one of the cultures belonging to a strain of fibroblasts derived from muscle had very suddenly given rise to a broad band of macrophages. A few days later a culture of the same age, but belonging to a strain of heart fibroblasts, behaved similarly. Less than two weeks later a third culture showed the same phenomena. This third culture, which had been treated for twenty-eight days in the flask when the transformation occurred, had been made from a strain of fibroblasts originating from bone periost, a strain which had been carried for twelve passages before the experiment was made. It was therefore quite obvious that the phenomenon was not limited to any one cell type. It is interesting to note that Carrel and Ebeling,[3] Fischer[4] and Ephrussi and Hughes[5] have reported the occasional occurrence *in vitro* of similar transformations, although the factors responsible for the changes have never been clearly defined.

After these and many similar observations had been made, new experiments were set up in an endeavor to duplicate as closely as possible every step in the treatment of these cultures in the hope that the changes might recur. And since this proved to be the case, we had a better opportunity for studying the predisposing conditions. Since, also, but a limited number of the cultures comprising the various experiments showed the phenomena, it was possible to make a comparative study of the general condition and rate of growth of cultures which had transformed and of those which had not. It was found that those cultures which had not transformed fell into two groups, namely, cultures which responded very favorably to the plasma treatment, as evidenced by the condition of the cells and their rate of proliferation, and those which could not adapt themselves to the new medium and very early succumbed when deprived of the abundant food substances which they had received before being placed under the conditions of the experiments. When transformation did occur, it seemed to take place at some critical period in the life of a culture in which the degeneration process was already quite evident, but was advancing at a relatively gradual rate.

These cells have been referred to as macrophages because they appeared identical with macrophages both in form and behavior. They were quite independent, very active, and showed no tendency to form a tissue. They also possessed the typical undulating membrane. Their origin was very easily ascertained. They were invariably budded off from the fibroblast-like cells at the periphery of a culture which showed unmistakable signs of degeneration. The cells from which the macrophages were derived were always very heavily granulated and distended. Several macrophages were usually pinched off from a single fibroblast, until finally nothing was left of it but a small remnant packed with the globules and granules of the original cell. When the transformation process had once begun, it continued with great rapidity. The macrophages wandered out into the medium at a uniform rate from the entire periphery, and, inasmuch as plasma is the optimal medium for their multiplication, they eventually covered an area which was, in some cases, twelve times as great as that finally covered by the colony of fibroblasts from which they were derived. The identity of the macrophages was further borne out by certain reactions, typical of blood and tissue macrophages, to alterations in the chemical constitution of the medium.

It seems reasonable to conclude that the macrophage and the fibroblast represent functional variations of the same cell type. The extent to which a cell changes its form depends, however, upon its physiological condition at any one moment and upon the chemical and physico-chemical properties of the medium. In order to determine the nature of such properties as may be responsible for these changes, it now becomes necessary to study the effect upon the cells of various constituents of the medium employed.

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FOR MEDICAL RESEARCH,
NEW YORK, N. Y.

[3] A. Carrel and A. H. Ebeling, *J. Exp. Med.*, 44, 261, 1926.

[4] A. Fischer, *Arch. f. exper. Zellforschung*, 3, 345, 1926.

[5] B. Ephrussi and Y. Hughes, *C. R. de la Soc. de biol.*, 105, 697, 1930.

BOOKS RECEIVED

ESSIG, E. O. *A History of Entomology.* Pp. vii + 1029. 263 figures. Macmillan. $10.00.

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STALLYBRASS, C. O. *The Principles of Epidemiology and the Process of Infection.* Pp. xii + 696. 104 figures. Macmillan. $8.50.